Reference

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FIELD ARTILLERY TARGET ACQUISITION

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FIELD ARTILLERY TARGET ACQUISITION

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Purpose and Scope

This manual is a guide for commanders, field artillery S2's and staffs of all combat arms. It pertains to field artillery target acquisition to include planning, employment, and coordination of all target acquisition means. Where the term *"artillery"* is used in this manual, it refers to field artillery. The material presented herein is applicable without modification to both nuclear and nonnuclear warfare.

2. Changes or Comments

Users of this manual are encouraged to submit recommended changes or comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be forwarded directly to Commandant, U.S. Army Artillery and Missile School, Fort Sill, Okla.

3. Definitions

a. Target Acquisition. That part of combat intelligence which involves the timely detection, identification, and accurate three-dimensional location of a target in sufficient detail to permit effective attack by weapons.

(1) *Direct target acquisition.* Target acquisition obtained by one intelligence collection means. For example, counter-mortar radar, forward observer, photograph.

(2) *Indirect target acquisition.* Target acquisition which is developed from evaluation of intelligence information supplied by two or more means. For example, a comparison of interrogation reports (POW) with reports of vehicle traffic (aerial radar) and reports of radio activity (COMINT).

b. Combat Surveillance. Continuous (all-weather, day and night) systematic observation of the battle area to provide timely information for tactical operations. The information collected (friendly as well as enemy) is obtained by both technical and nontechnical means.

c. Observation. The examination or study made of such things as terrain, artillery fire, or atmospheric conditions to obtain information of military value.

(1) *Direct observation.* Observation by direct vision, or vision aided by electronic or optical instruments.

(2) *Indirect observation.* Observation through study of imagery.

d. Counterbattery. The term counterbattery includes fires on mortars, cannon, rockets, and missiles. Counterbattery intelligence has as its objective the gathering of complete information pertaining to hostile firing means.

e. Others. For other pertinent definitions see AR 320–5.

Section II. TARGET ACQUISITION AGENCIES

4. General

a. Target acquisition agencies are part of the intelligence gathering agencies of the force as a whole, and as such, are major components of the combat intelligence system at all echelons.

b. Artillery target acquisition agencies provide a large portion of the target acquisition effort. Other agencies also contribute to the overall effort. Tactical Air Force elements contribute information in the nature of photo and visual reconnaissance reports and strike reports. Army combat elements contribute information from front line observers, patrol reports, and other visual and electronic means. Other sources of information which may be exploited to result in target locations are:

(1) Shelling reports.
(2) Mortar reports.
(3) Reconnaissance patrols.
(4) Long-range patrols.
(5) Combat patrols.
(6) Prisoners of war.
(7) Line crossers.
(8) Agents.
(9) ELINT.
(10) COMINT.
(11) ASA.
(12) Special forces.
(13) Stay-behind forces.

5. Artillery Target Acquisition

a. Although artillery intelligence agencies collect and report all information of military significance, their primary concern is gathering and processing target information of importance to artillery operations. The target acquisition effort is continuous and aggressive and extends through the zone of action in order to provide for the full exploitation of artillery's firepower capabilities. Artillery information is disseminated in the most expeditious manner to assure delivery of effective and timely fire; therefore, artillery target acquisition elements work closely with all fire support and coordinating agencies.

b. Target data obtained from organic artillery target acquisition agencies are plotted on the same common reference grid as that used to plot the artillery weapons positions. This reduces reaction time and facilitates rapid neutralizing or destructive fires. The majority of hostile targets may be fleeting in nature; therefore, immediate responsiveness from friendly firing units is essential and there should be no delays in the transmission or intelligence processing of target information.

c. Target information is collected by continuous planning and systematic direction of the collection efforts. Effective utilization of the sources and agencies available for target information requires that the artillery S2 know the capabilities and limitations of these agencies.

6. Organic Artillery Target Acquisition Agencies

a. General. Target acquisition means are organic to the field artillery target acquisition battalion (FATAB), headquarters and headquarters battery of division artillery, and headquarters and headquarters battery of the 105-mm howitzer battalion and other artillery battalions to a lesser extent.

b. Field Artillery Target Acquisition Battalion. The field artillery target acquisition battalion, assigned to corps artillery, consists of a headquarters and headquarters battery and three field artillery target acquisition batteries. Unlike other artillery units, the FATAB is an organization whose primary mission is to furnish target data to the field artillery.

(1) *Headquarters and headquarters battery* (fig. 1)—Headquarters battery.
   (*a*) Operations platoon.
   (*b*) Survey platoon.
   (*c*) Drone platoon.

(2) *Target acquisition battery* (fig. 2).
   (*a*) Processing section.

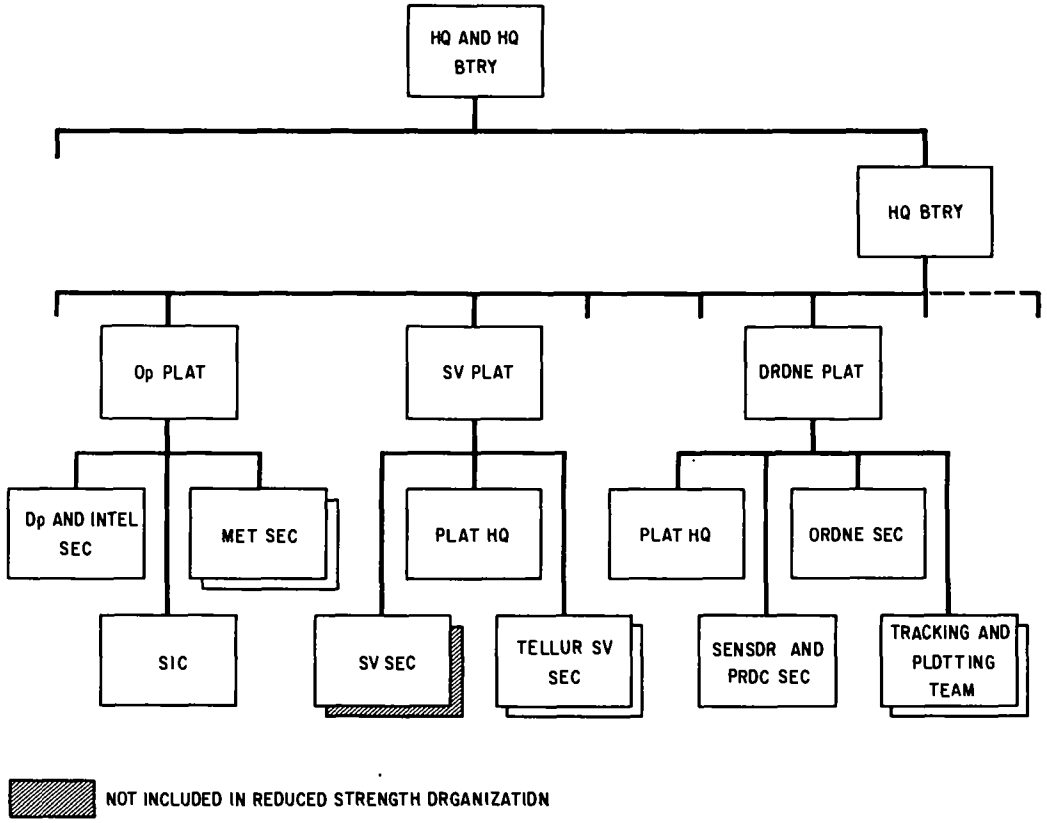

Figure 1. Target acquisition and supporting agencies within headquarters battery, field artillery target acquisition battalion.

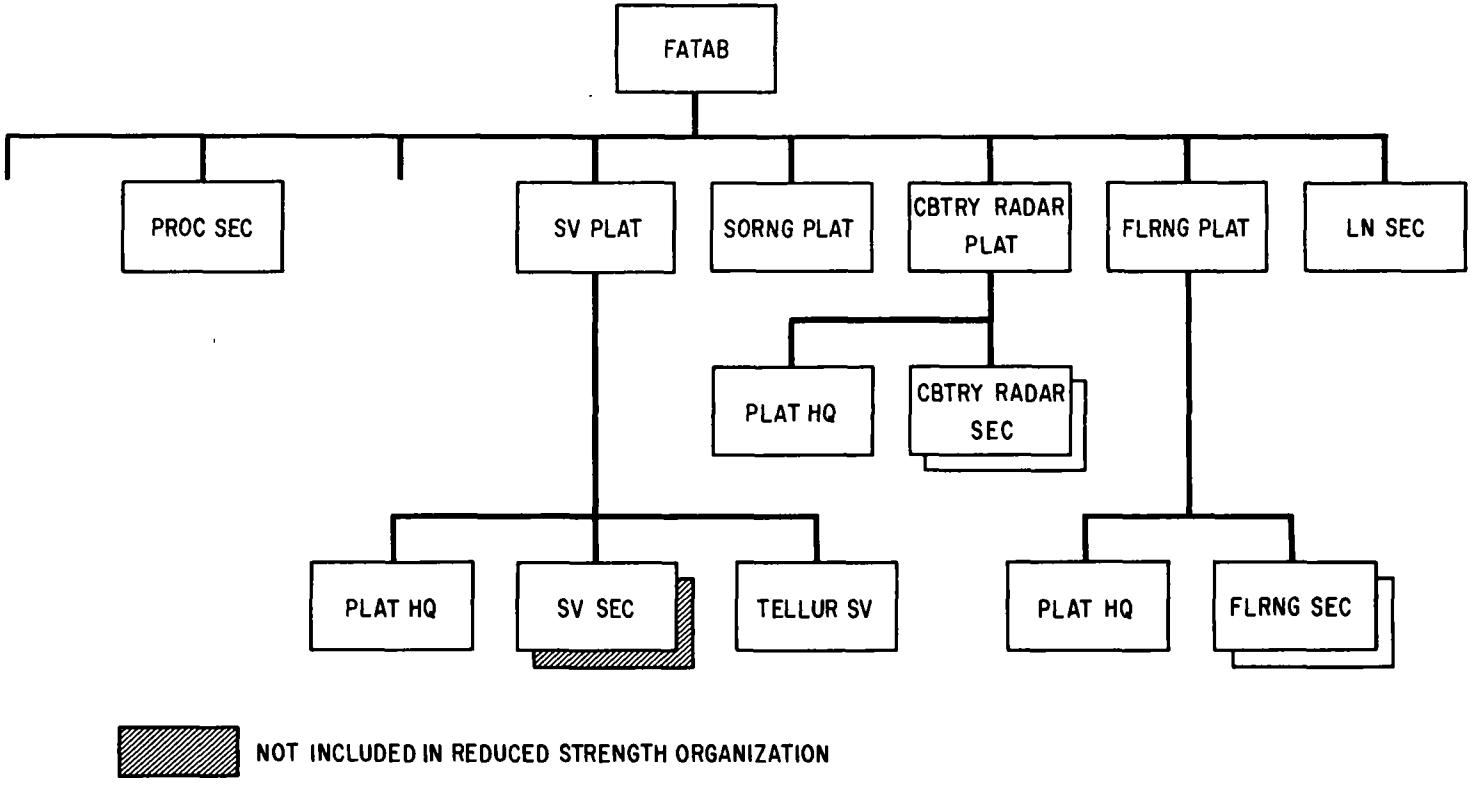

Figure 2. Target acquisition and supporting agencies within the target acquisition batteries of the field artillery target acquisition battalion.

(*b*) Survey platoon.
(*c*) Sound ranging platoon.
(*d*) Counterbattery radar platoon.
(*e*) Flash ranging platoon.
(*f*) Liaison section.

c. Division Artillery. The target acquisition platoon (fig. 3) of the division artillery headquarters and headquarters battery includes those elements actively engaged in locating targets together with the agencies required to furnish data to the weapons delivery systems. They are—

(1) Platoon headquarters.
(2) Survey information center.
(3) Survey section.
(4) Surveillance radar section.
(5) Visual airborne target location section.
(6) Meteorological section.

d. 105-mm Howitzer Battalion (hereafter referred to as the direct support (DS) battalion). The target acquisition platoon

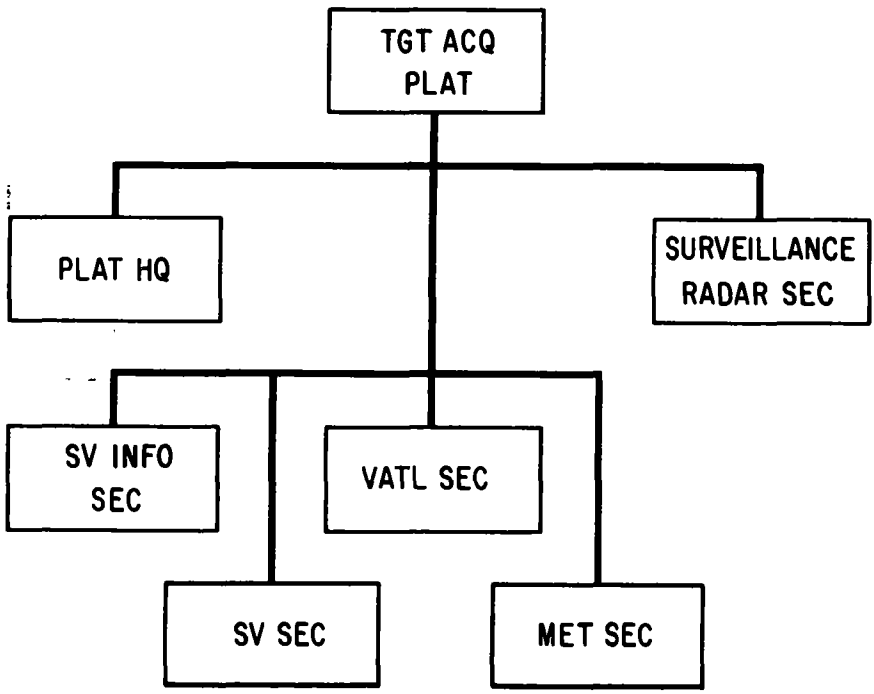

Figure 3. Target acquisition platoon, headquarters and headquarters battery division artillery, armored, mechanized, infantry, or airborne division.

(fig. 4) consists of—

(1) Platoon headquarters.
(2) Survey section.
(3) Radar section.

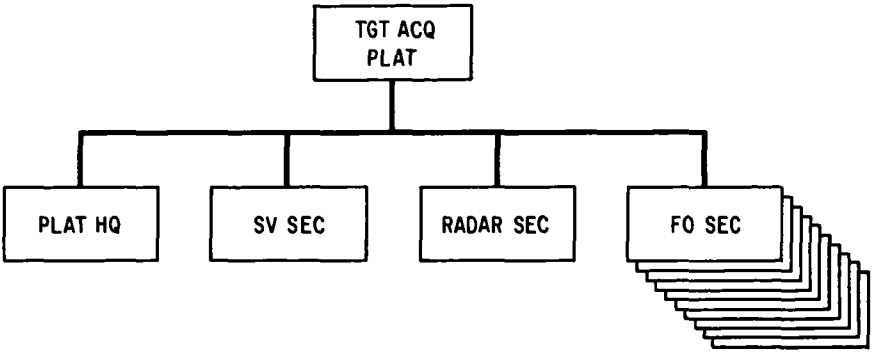

Figure 4. Target acquisition platoon headquarters and headquarters battery, 105-mm howitzer battalion, armored, mechanized, infantry, or airborne division.

Section III. TACTICAL EMPLOYMENT OF TARGET ACQUISITION AGENCIES

7. General

a. The tactical situation and the width of the front will govern deployment of artillery target acquisition agencies. Devices and systems employed by these agencies normally provide either direct or indirect observation at ranges up to 20 km and in addition, the drone system is capable of indirect observation up to 65 km from the forward edge of the battle area (FEBA). Both corps and division artillery target acquisition elements are normally employed within 2 or 3 km of FEBA. In selecting positions for radar, sound, flash, and drone units, the mission of the unit, the situation, the characteristics of the equipment, and the characteristics of enemy materiel are considered. Positions are selected where the terrain best facilitates operation of the equipment. The CP's of the firing batteries normally will be located in the close proximity of a division artillery or separate group FDC to facilitate operations and take advantage of local security measures.

b. The target acquisition unit commander advises higher headquarters on the technical capabilities and limitations which will affect the employment of his unit under the existing tactical conditions.

8. Tactical Employment of FATAB

a. Tactical missions that may be assigned to the FATAB are as follows:

(1) *General support of corps artillery.* When assigned this mission the FATAB commander exercises maximum centralized control of his subordinate units. The FATAB operations section is normally co-located with the corps artillery operations section to permit rapid and timely reaction to target and general intelligence collected by acquisition agencies within the battalion. The FATAB is deployed to operate in the zone of action of the corps and will direct deployment of its batteries within this zone as required. Battery CP's normally will be located in close proximity of a division artillery or field artillery group FDC to facilitate operations and for local security. The battalion will displace on order of the corps artillery commander; the batteries will displace on order of the battalion commander.

(2) *Direct support of division artillery or field artillery group.* While the FATAB is normally assigned a mission of general support, one or more of the target acquisition batteries may be assigned the mission of direct support of a division artillery or field artillery group. The battalion exercises a lesser degree of control of its batteries when they are assigned a direct support mission. Normally the battery processing section is co-located with the supported unit operations center to facilitate rapid and timely reporting of all target and general intelligence information. This information is also transmitted to Corps Artillery by supported unit and by the TA Processing Section to the FATAB Operations Center. This will provide complete and integrated target acquisition coverage of the corps zone of action. The battery will operate in the zone of action of the supported unit. This does not mean that the battery is restricted to the boundaries of the supported unit for deployment of its platoons; but must be able to locate targets within the zone of action of the supported unit. The battery will displace on order of the supported unit or the FATAB Commander, as directed. The target acquisition batteries normally will be employed in direct support of divisions under the following conditions:

(*a*) When there is an exceptionally wide corps front.

(*b*) In the offensive phase of combat.

(*c*) During rapidly changing situations requiring timely displacement of elements to assure continuous target acquisition coverage.

(*d*) When communications (terrain or distance) do not permit the FATAB commander to exercise full control of his batteries.

b. A target acquisition battery may be attached to the artillery of a division on a special mission, or to an artillery element with a task force. In this role the processing section of the battery is co-located with the supported artillery operations center to permit rapid and timely reaction to collected intelligence information. The battery will operate in the zone of action of the unit to which attached, and will displace as directed.

c. Liaison will be established as follows:

(1) FATAB—as directed by corps artillery.

(2) FATA battery—as directed by FATAB or supported unit according to the mission assigned.

9. Tactical Employment of Division Artillery Target Acquisition Agencies

All target acquisition systems within the division artillery structure are normally employed by the individual unit commander in support of his mission. Overall guidance and coordination of the total division artillery collection effort is the staff responsibility of division artillery S2.

a. Target Acquisition Platoon, Headquarters and Headquarters Battery Division Artillery.

(1) The ground surveillance radar is employed under the supervision of the division artillery S2. Since the radar supports the entire division artillery, the area in which it is employed is dependent upon the tactical situation. This area is designated by the division artillery S2.

(2) The Visual Airborne Target Location System (VATLS) is employed under the supervision of the division artillery S2. The aircraft operate under the administrative control of the division artillery aviation officer. The ground support equipment should be emplaced within one of the DS battalion areas for security.

b. Target Acquisition Platoon, Headquarters and Headquarters Battery, DS Battalion. The radar section is normally employed under the supervision of the battalion S2. It is normally employed to cover the zone of action of the supported unit.

10. Displacements

Timely and rapid displacements of target acquisition units are necessary to provide continuous support. Target acquisition sup-

port is maintained during displacements by displacing platoons by echelon. Displacements are accomplished as rapidly as possible so that operation can be resumed with a minimum of delay and to minimize the possibility of the displacing unit's detection and attack by the enemy. Command posts are normally displaced by echelon to insure continuity of control. Initial communication is installed and operations are begun at the new command post prior to displacement of the old command post. All target acquisition agencies and fire support elements should be placed on a common grid as soon as possible to facilitate the timely and accurate delivery of fire on the located targets. When possible, survey is completed before displacement is begun. Survey requirements for target acquisition systems are discussed in detail in chapter 1, section V.

11. Relief in Combat

a. General. Relief in combat is of two general types: Passage of lines and relief in place. Either type of relief may be accomplished by target acquisition agencies. Relief during passage of lines is accomplished by the relieving unit installing and occupying the forward positions of the unit being relieved. This type relief entails more detailed planning and cooperation between incoming and outgoing target acquisition units (FM 6–120).

b. Warning Orders. When a relief in place or a passage of lines is to be made, warning orders are issued by the commanders of the next higher headquarters, the relieving unit, and the relieved unit. Warning orders should include the hour the movement for the relief is to begin and end, the zone of operation of the relieving unit, and any restrictions imposed upon reconnaissance parties.

Section IV. DUTIES OF KEY PERSONNEL

12. General

A thorough development of artillery intelligence is necessary for the proper employment of artillery units, the timely effective delivery of fire, and coordination of movement and fire support with the supported unit and other supporting arms. The efficiency with which the artillery fulfills its mission depends to a great extent on adequate and timely target intelligence.

13. Responsibility for Intelligence (S2)

a. Obtaining all intelligence essential to artillery operations.

b. Initiating a systematic and coordinated search by all available collecting agencies for target information. To accomplish this he must—

(1) Coordinate, through the normal chain of command and through staff contacts, the work of artillery intelligence personnel in lower echelon artillery units.
(2) Coordinate with the S3 the observation facilities, including Army aviation, used for artillery target acquisition.
(3) Maintain close liaison with the intelligence sections of higher, lower, adjacent, and supported units for exchange of information and for mutual assistance in the collection of target information.
(4) Foresee the need for, obtain and distribute maps, trig lists, photomaps, and aerial photographs.
(5) Provide for the study and interpretation of imagery and, when imagery interpreter teams are available, supervise their activities.
(6) Direct the operation of counterbattery intelligence activities.
(7) Process requests for reconnaissance missions by Army and Air Force aircraft and the missions to be flown by drone aircraft. Priorities are established and missions assigned in coordination with the S3.
(8) Prepares the target acquisition plan.

c. Collecting, evaluating, and interpreting information and rapidly disseminating pertinent target information and intelligence.

d. Keeping the artillery commander, staff, fire direction center (FDC), and subordinate units informed of the enemy situation and capabilities.

e. Collaborating closely with the S3 or fire support coordinator (FSC) on intelligence matters to include meteorological data available from field army sources.

f. Examining maps, photomaps, and imagery to determine reliability of control and disseminating this information to subordinate units.

g. Preparing and distributing intelligence reports.

h. Keeping the S2 situation map and any other records required by the S2 section.

i. Furnishing pertinent data for inclusion in the command report.

j. Preparing a plan for, and supervising the execution of, counterintelligence measures (FM 30–5).

k. Obtaining and reporting information and intelligence relative to the force commander's essential elements of information (EEI).

l. Obtaining and providing information and intelligence requested by subordinate and adjacent units.

m. Fulfill the commanders requirements for information on weather for use in the intelligence estimate. To do this, the intelligence officer must be familiar with the Air Weather Service (AWS) role in providing weather support to the field army. The artillery S2 coordinates with the AWS through the applicable Air Force weather staff officer at division, corps, or army.

n. Informing the survey officer of intelligence matters affecting survey operations.

o. Supervising artillery intelligence training.

14. Counterbattery Intelligence Officer (CBIO)

The counterbattery intelligence officer (CBIO) is the corps (division) artillery intelligence staff officer responsible for securing accurate information of the enemy indirect fire weapons and for recommending appropriate counterbattery fire. The CBIO assists the corps (division) artillery S2 and S3 by furnishing counterbattery information required to develop a counterbattery program in the conduct of deliberate operations, to develop and estimate the hostile artillery situation for the force commander and higher headquarters, and to facilitate intelligence discrimination in the selection of counterbattery targets of opportunity. In addition, he—

a. Collects and consolidates counterbattery information from all intelligence sources.

b. Evaluates, interprets records, and disseminates counterbattery information.

c. Assists in damage assessment.

15. Reconnaissance and Survey Officer

In the performance of his duties, the survey officer is closely associated with target acquisition agencies in that the devices employed by these agencies require survey control. Predicted fire techniques require that a common grid be established between delivery systems and the targets attacked by them. The transfer of accurate target data is impossible without control for the target acquisition devices. His specific duties are to—

a. Prepare survey plans.

b. Obtain survey control and extend control to lower echelon artillery units.

c. Supervise fieldwork of the survey platoon.

d. Execute survey plans.

e. Conduct reconnaissance for routes, position areas, and observation posts as directed by the commander.

f. Supervise survey training within the command.

g. Plan continuously for future reconnaissance and extension of survey.

h. Collaborate closely with the S2 and S3 in securing needed information concerning target location, observation, routes, and future position areas.

i. Exchange survey data and information with the survey officers of higher, lower, and adjacent units. This may include establishing a survey information center.

j. Determine the accuracy of available maps.

16. Radar Officer

The duties of the radar officer are to—

a. Advise the commander and staff on all radar matters.

b. Advise and aid the S3 in organizing and supervising radar training programs.

c. Submit necessary reports and keep pertinent records.

d. Supervise radar maintenance.

e. Provide liaison on radar matters with higher headquarters.

f. Advise the commander and staff on radar coverage.

g. Advise and assist the S4 in the procurement of radar supplies.

h. Maintain clutter and coverage diagrams as appropriate.

i. Advise the commander and staff regarding electronic countermeasures and antijamming techniques pertaining to radar and advise the S3 of training requirements in these areas.

17. Target Acquisition Platoon Leader

The duties of the target acquisition platoon leader are to—

a. Advise the commander and staff in matters relating to planning for, and employment of, elements of the target acquisition platoon.

b. Assist the S2 in CBIO duties as directed.

c. Direct and supervise the training of platoon personnel and employment of platoon elements.

Section V. SURVEY APPLICATIONS TO TARGET ACQUISITION

18. Purpose of Artillery Survey

The purpose of artillery survey is to provide a common grid for firing units and target locating installations. Target locations are determined by the extension of survey control from the target locating devices. Technical characteristics of survey equipment are discussed in detail in section V, appendix V.

19. Target Location by Extension of Survey Control

a. Connection survey is that survey performed for the purpose of locating the target area survey and the position area survey on a common grid.

b. Target area survey is that survey performed for the purpose of establishing the target area base and locating critical points in the target area. For detailed discussion see FM 6–2, Artillery Survey.

20. Ground Based Visual Target Acquisition Systems

a. Forward Observers. Often, the rapid and frequent displacement of forward observers with infantry companies makes it extremely difficult to provide survey for their positions. Position requirements are usually met by map inspection or by estimation. Direction may be obtained by use of a compass or by map inspection.

b. Artillery Battalion Observation Posts. Survey control for artillery battalion observation posts is provided by the surveyors organic to the unit. Location of registration and restitution points are determined by the survey intersection method from two or more OP's. Fifth-order survey procedures are used to establish survey control for OP's.

c. Flash Ranging Observation Posts. Survey control for flash ranging observation posts is provided by the surveyors organic to FATAB. Fifth-order survey procedures are used to establish survey control with orientation accurate to ± 1 mil.

21. Radar Target Acquisition Systems

a. Ground Surveillance Radar. Position and direction data for ground surveillance radar should be furnished by survey personnel. For hasty operations when large scale maps are available, map inspection data can be used. Better results can be achieved when fifth-order survey control for positioning and orientation of radar is provided. This radar has a unique survey requirement in that it requires distance to reference points in addition to direction.

b. Counterbattery and Countermortar Radar. Fifth-order survey control performed by organic survey personnel is provided for the positioning and orienting of the counterbattery and countermortar radars.

22. Sound Target Acquisition Systems

Fourth-order survey control is required for each sound microphone of the target acquisition battery. The target acquisition battery surveyors normally perform the sound base survey in conjunction with other survey requirements.

23. Aerial Target Acquisition Systems

a. Visual Airborne Target Location System. The plotting and tracking radar of the visual airborne target location system (VATLS) must be surveyed to fourth-order accuracy. The gyroscope in the stable platform must be oriented prior to each mission.

b. Drone Target Acquisition Systems. The field artillery target acquisition battalion must provide fifth-order survey control to the tracking and plotting system of the drone platoon (SD–1).

24. Other Target Acquisition Systems

a. Within the corps and division areas nonartillery agencies may require survey for their equipment to facilitate target acquisition. This survey is normally provided by the artillery surveyors except where the accuracy of survey required exceeds the artillery survey capability. In those cases the survey is provided by engineer topographic survey teams. These agencies requiring survey include the tracking and plotting radar section, aerial surveillance and target acquisition platoon, aviation battalion general support company, armored, infantry, mechanized, and airborne division; ASA; COMINT; and ELINT installations.

b. Long range patrols, agents, and U.S. Army special forces have a major target acquisition capability. Extended target area survey facilitates their operations and increases the accuracy of the target information which they report.

Table I. Survey Requirements for Target Acquisition Systems

REQUIREMENT	VISUAL			RADAR			SONIC	AERIAL	
	FORWARD OBSERVERS	AIR OBSERVERS	BATTALION AND FLASH OBSN POSTS	GROUND SURVEILLANCE	COUNTER-MORTAR (Q4)	COUNTER-BATTERY (Q10)	SOUND RANGING BASES	VATL	SD-1
1. WITH SUITABLE MAPS AVAILABLE									
a. POSITION	MAP INSPECTION	MAP INSPECTION	Fifth-order	MAP INSPECTION	Fifth-order	Fifth-order	Fourth-order	Fourth-order	Fifth-order
b. DIRECTION	MAP INSPECTION OR COMPASS	MAP INSPECTION	± 1 MIL	± 1 MIL	± 1 MIL	± 1 MIL	N/A	± 1 MIL	± 1 MIL
c. SURVEY PERFORMED BY	N/A	N/A	ORGANIC	DIV ARTY	DS BN	TA BTRY	TA BTRY	DIV ARTY	FATAB, DIV ARTY, D/S BN
2. MAPS NOT AVAILABLE									
a. POSITION	ESTIMATION	ESTIMATION	ASSUMED GRID, Fifth-order	ASSUMED GRID, Fifth-order	ASSUMED GRID, Fifth-order	ASSUMED GRID, Fifth-order	ASSUMED GRID, Fourth-order	ASSUMED GRID, Fourth-order	ASSUMED GRID, Fifth-order
b. DIRECTION	COMPASS	N/A	± 1 MIL	± 1 MIL	± 1 MIL	± 1 MIL	N/A	± 1 MIL	± 1 MIL
c. SURVEY PERFORMED BY	N/A	N/A	ORGANIC	DIV ARTY	DS BATTALION	TA BTRY	TA BTRY	DIV ARTY	FATAB, DIV ARTY, DS BN

Note. **For accuracy definitions, see FM 6–2.**

Section VI. METEOROLOGY

25. General

The wide dispersion of army forces on the modern battlefield and the sophistication of current weapon systems has increased the Army's requirements for information on atmospheric conditions. This information can be broken down into two general areas: information concerning weather and climate, and artillery meteorological data. Information concerning weather and climate encompasses weather forecasts, weather summaries, and climatological reports required for military tactical and strategic operations. Artillery meteorological data furnished by the Army includes ballistic meteorological messages, sound ranging messages, wind information for fallout prediction, atmospheric data for the Air Weather Service detachments with the field army, pressure data for missiles, and low-level wind data for rockets. Technical characteristics of meteorological equipment are discussed in detail in section I, appendix V.

26. Staff Supervision

a. The weather services provided to the field army by the Air Weather Service are accomplished under the staff supervision of the intelligence officer at each echelon. This weather support is outlined in paragraph 30.

b. Ballistic meteorological data produced by artillery meteorological sections is not classified as intelligence weather data. Artillery meteorological sections are part of the artillery weapons system and their operations and activities, to include communications and scheduling required for dissemination of meteorological messages, is accomplished under the staff supervision of the operations officer at each echelon.

27. Artillery Meteorological Sections

Within each field army there is a network of artillery meteorology (metro) sections which exist for the purpose of conducting atmospheric soundings and disseminating current meteorological data. Each division artillery has one meteorological section; and the corps FATAB has two. Thus, a 12 division, three corps field army has at least 18 metro sections continuously processing atmospheric data. Although they are an additional source of weather data, these sections are not trained or equipped to perform weather forecasting.

28. Mission of Artillery Meteorological Sections

The mission of artillery metro sections is to support the meteorological needs of the field army by providing, as required—

a. Ballistic messages.

b. Meteorological data for fallout prediction.

c. Sound ranging messages.

d. Meteorological data to air weather service units with the field army.

e. Meteorological data to missile units.

29. Dissemination of Meteorological Data

Due to the temporary nature of current meteorological information, timely distribution of meteorological messages is essential. The best means of transmitting meteorological data is through the use of radioteletype circuits such as the corps and division artillery command/fire direction nets (RATT).

30. Air Weather Service Support Within the Field Army

a. By joint regulation, the Air Weather Service (AWS) of the U.S. Air Force provides units properly organized, equipped, and trained, to fulfill the requirements of the Army for weather forecasts, weather summaries, and climatological reports. Forecasts are prepared by AWS for the Army on both a routine and a special basis. Routine forecasts normally cover periods of 24 hours, 48 hours, and 3 to 5 days. Forecasts are based on the information forwarded to the Air Weather Service forecast section with the field army by the worldwide weather facilities of the AWS and on local meteorological data collected within the field army area by both AWS personnel and artillery meteorological sections.

b. The AWS support of the field army is accomplished through an Air Force staff weather officer (SWO) at division, corps, and army headquarters. Each SWO is supported by an AWS detachment which includes both observers and forecasters. Communication support to include both teletypewriter and facsimile circuits is provided to the AWS detachment by the signal unit organic to the supported command. The SWO operates under the staff supervision of the G2, and, at corps and division headquarters, he is also the AWS detachment commander. He advises the commander and his staff on matters related to weather and climate. He arranges, through AWS channels, for climatological studies and summaries as required, coordinates the delivery of routine and special forecasts, and serves as the liaison officer between the AWS detachment and the Army element.

CHAPTER 2

TARGET ACQUISITION SYSTEMS

Section I. VISUAL SYSTEMS

31. General

A target acquisition system consists of the equipment necessary to perform timely detection, identification, and three-dimensional location of ground targets in sufficient detail to permit the effective employment by weapons. Systems available to the artillery are discussed in paragraphs 32 through 49.

32. Forward Observers

Forward observers perform a very important target acquisition function; however, the distances over which they can acquire target information is limited. Forward observer (FO) parties are assigned on the basis of one per infantry (tank) company. Although the forward observer's primary mission is to request fire support on targets in the supported company's zone of action, he can be of great assistance to the S2 in collection of general battlefield information within the limits of his field of view.

33. Observation Posts

Each cannon-type field artillery battalion should establish its own observation posts (OP) to supplement the observation posts of the forward observers with the frontline units. Because observation is so important, artillery units are usually required to install OP's at points that will provide overlapping coverage of the entire front. Such observation, when integrated with the observation provided by the forward observers with the supported units, and by the forward infantry units, reduces the possibility of close-in undetected surprise moves by the enemy. It also supplements information contributing to the employment of full firepower against the enemy. Battalion OP's are, as time permits, located by survey methods (FM 6–2). The base formed by two or more OP's located by survey may be used for location of targets by intersection. For

details of 01–02 base operations, see short base operations, FM 6–122.

34. Air Observation

Air observation provides an important means of target acquisition. It permits locating targets that are defiladed from ground observers and makes observation possible at greater depths into the enemy area. Air observation is accomplished by observers in Army and Air Force aircraft. Under some situations, tactical Air Force aircraft assist in the adjustment of fire of medium and heavy cannon artillery weapons. The tactical air force aircraft may also assist in visual and photographic aerial reconnaissance. Army surveillance and observation aircraft are also used to adjust light and medium range cannon artillery fires. The type aircraft best suited for the particular mission is utilized. Army aircraft are highly responsive to mission requirements. Aerial observation systems are discussed in detail in section IV of this chapter.

35. Flash Ranging

a. General. Flash ranging is the procedure used to locate points in the target area by visual observation and intersection from two or more observation posts. Since optical instruments are used by the flash ranging platoon, line of sight to the target is required. These instruments are passive devices and if properly concealed are difficult to locate by the enemy. Technical characteristics of flash ranging are discussed in detail in section IV of appendix V.

b. Organization. One flash ranging platoon is organic to each target acquisition battery of the field artillery target acquisition battalion. This platoon is completely mobile and can operate 24 hours a day.

c. Missions. The flash ranging platoon performs five principal missions. They are—

(1) Location of hostile artillery.
(2) Registration and adjustment of friendly artillery.
(3) Collection of battlefield information.
(4) Comparative calibration.
(5) Verification of location of friendly nuclear bursts.

d. Tactical Employment. Flash ranging can be accomplished in both mobile and static warfare.

(1) In mobile warfare, flash ranging platoons are employed aggressively in order to provide sustained coverage. The initial installation usually employs a short base with expansion to a long base whenever possible. Adjustment on active targets is the rule, rather than the reporting of a corrected target location.

(2) In static warfare the long base is usually employed. The initial installation may or may not be short base, but an expansion to a long base is normally carried out as quickly as the situation permits. Corrected locations of targets are reported to higher echelons.

c. Long Base. The flash ranging long base contains four OP's located to fifth-order survey accuracy. With this type base, coordinates of hostile artillery can be determined at ranges up to the limit of visibility with accuracies from 0 to 50 meters. Accuracies are assigned to each location reported (FM 6–122). These accuracies are utilized in evaluating reported locations. The width of the area of coverage may extend from 6,000 to 10,000 meters.

f. Short Base. The short base, consisting of two OP's, is used when an analysis of the four primary considerations (time available, terrain, communications, and survey) shows that use of a long base is impractical or impossible. When the OP's are located to fifth-order accuracy, targets are reported by coordinates. When survey is not available, fire is adjusted on targets. The width of the area of coverage of the short base is approximately 2,000 meters. The short base can be installed in 30 to 90 minutes. Short base operations are similar to 01–02 base operations.

Section II. RADAR

36. General

Three types of radars are used by the field artillery-countermortar, counterbattery, and ground surveillance. All are active devices, and therefore subject to electronic countermeasures. Radars can be employed in both mobile and static warfare. In mobile warfare, radars are employed aggressively in order to provide sustained coverage. In static warfare, alternate positions should always be prepared to circumvent the enemy in his efforts to neutralize the radar. Countermortar and counterbattery radars have a mobility comparable to that of a towed 155-mm howitzer.

37. Countermortar Radars

Countermortar radars locate mortars by detecting the position of the mortar projectile at two points in space. The data obtained from these two points is inserted into an analog computer which extrapolates the trajectory of the projectile, determines the origin, and reads out the hostile mortar location. For more detailed information see appendix V, section II.

a. Organization. One countermortar radar section is organic to each of the direct support 105-mm howitzer battalions in the in-

fantry, mechanized, armored and airborne divisions. The countermortar radar section is organized to operate 24 hours a day.

b. Missions.

(1) Location of hostile artillery weapons.

(2) Adjustment and registration of friendly artillery.

c. Tactical Employment.

(1) The direct support battalion commander normally designates the general position area in which the radar section may select positions. Such designations should encompass an area sufficiently large to enable the radar officer (chief of section) to select the actual radar location based on technical considerations affecting the operation of the radar. The radar position should be adjacent to one of the firing batteries. Such a position simplifies communications, facilitates survey and logistics, and enables the section to take advantage of any existing defensive perimeter. Depending on the mission, terrain, and tactical situation the radar position area will be located from 2,000 to 4,000 meters behind the forward edge of the battle area. This gives the radar section flexibility of action in both the offense and the defense. During offensive action, the position should be well forward to avoid early displacement. In the defense, the position will be located further rearward in a position area designated by the division artillery commander in order to provide depth to the radar operations of the defensive force as a whole.

(2) The battalion commander also designates the sector of search for the radar. This sector of search will normally coincide with the zone of action of the supported unit. The coordination of the sectors of search of all countermortar radars within the division is the responsibility of the division artillery S2. For a more detailed discussion of tactical employment and position requirements see FM 6–161.

(3) Radar clutter and coverage diagrams will be prepared, and must be provided to the battalion S2 at the earliest practical time to facilitate the preparation of the target acquisition capabilities chart.

38. Counterbattery Radar

The counterbattery radar locates artillery weapons and shell bursts by determining the origin or terminus of the trajectory of a projectile by graphic calculations based upon radar observa-

tions of the projectile in flight. For a more detailed discussion of the counterbattery radar see appendix V, section IV.

a. Organization. One counterbattery radar platoon is organic to each target acquisition letter battery, field artillery target acquisition battalion. Each platoon consists of two radar sections. Each counterbattery radar section is organized to operate 24 hours a day.

b. Missions.

(1) Location of hostile artillery weapons.

(2) Adjustment and registration of friendly artillery.

c. Tactical Employment.

(1) The battery commander of the target acquisition battery designates the general position areas for the battery's two radar sections. Normally he will assign positions on both flanks of the zone of responsibility. If possible, these positions should be located near an adjacent unit. Depending on the mission, terrain, and tactical situation, the radar position will be located from 2,000 to 4,000 meters behind the forward edge of the battle area. The battery commander will designate the sector of search for each radar. The final coordination of sectors of search of all counterbattery radars within the corps is the responsibility of the FATAB S3. After being informed of the general areas in which to locate the radar positions, the radar officer (chief of section) makes the final selection of the radar position based on tactical and technical considerations. For a more detailed discussion of position requirements see FM 6–160.

(2) Radar clutter and coverage diagrams will be prepared and must be provided to the FATAB S3 at the earliest practical time to facilitate the preparation of the target acquisition capabilities chart.

39. Ground Surveillance Radar

Ground surveillance radars detect moving ground targets, thus providing an excellent means of determining enemy activity in the forward battle area. Since the target is moving, the frequency of the reflected energy is slightly different from the transmitted energy. This frequency difference is within the audio range and is amplified to alert the operator that the radar has detected a target. The audio signal is a characteristic of a particular target and further assists the operator in identification. Line of sight conditions must exist between the radar antenna and the target. The ground surveillance radar must be emplaced on a vantage point to exploit its observation capability. Because of this employ-

ment it is susceptible to visual detection. Therefore, it will normally be employed during darkness or periods of reduced visibility. For a more detailed discussion see appendix V, section II.

a. Organization. The target acquisition platoon of the division artillery headquarters and headquarters battery, infantry, mechanized, armored and airborne divisions include one surveillance radar section. This section is mobile and air transportable, air landed, in Phase II of an airborne operation.

b. Missions.

(1) The detection and identification, by type, of moving ground targets during periods of darkness or reduced visibility.

(2) Vectoring of patrols or combat elements.

c. Tactical Employment.

(1) The surveillance radar is used by the artillery to monitor preselected key areas on the battlefield to supplement observation during hours of darkness or reduced visibility. These key areas may be likely avenues of approach or other critical areas. The section reports the time and coordinates of the future location of moving targets observed. This report may be sent either directly to a firing battery or an appropriate FDC as directed. The location information is rapidly converted to firing data to facilitate timely interdiction fire on the target.

(2) The general position area in which the radar officer may select positions is designated by the division artillery commander. Such designation is made based on the recommendations of the intelligence officer (S2) and should encompass an area sufficiently large to enable the radar officer (chief of section) to select the actual radar site, based on technical considerations affecting the operation of the radar. The position should be such as to simplify communications, facilitate survey and logistics, and enable the section to take advantage of any existing defensive perimeter. Depending on the mission, terrain and tactical situation, the radar position area would be located from 1,000 to 2,000 meters behind the line of contact. This would give the radar section flexibility of action in both the offense and defense. During offensive action, the position should be well forward to avoid early displacement. In the defense, the position should be located further rearward in a position area designated by the division artillery commander in order to provide depth to the radar operations of the defensive force as a whole. For a more detailed discussion of

employment and position requirements see FM 6–162.

(3) Areas of surveillance or coverage must be reported to the Division Artillery S2 by the radar section for inclusion in the division target acquisition capabilities chart.

Section III. SOUND

40. General

Sound ranging is the procedure used to locate the source of a sound wave by measuring the relative times of arrival of the sound wave at several accurately located microphones. Sound ranging has proved to be a productive target acquisition means for locating hostile artillery. Sound ranging locates hostile artillery pieces which are hidden from visual observation. It is a passive device, not subject to countermeasures. It is very effective in fog since it does not require line of sight to the target. On the other hand mountainous terrain materially affects operations, depending on the relative locations of the base and sound sources and the ground contours of the area under consideration. Heavy firing by friendly artillery tends to confuse interpretation of the sound record. Under high wind conditions, sound ranging is ineffective. Sound ranging is not effective in locating in nuclear bursts. Technical characteristics of sound ranging are discussed in detail in section III, appendix V.

41. Sound Ranging Platoon

a. Organization. Each target acquisition battery of the field artillery target acquisition battalion is authorized one sound ranging platoon. This platoon is completely mobile and can operate 24 hours a day.

b. Missions. The sound ranging platoon performs three principal missions. They are—

(1) Location of hostile artillery.

(2) Registration and adjustment of friendly artillery.

(3) Collection of battlefield information.

c. Tactical Employment. Sound ranging can be accomplished in both mobile and static warfare. In mobile warfare, sound ranging platoons are employed aggressively in order to provide sustained coverage. Initial installations are usually a hasty base with expansion to a deliberate base, if time permits. Adjustment on active targets is the rule for hasty base operations, rather than the reporting of true coordinate target locations. Sound ranging installations employed in static warfare are usually of the deliberate type. Initial installation may or may not be the hasty base, but expansion to a deliberate installation is always carried

out. Corrected locations of targets will be reported to appropriate higher echelon (battery or battalion) according to mission assigned.

(1) *Deliberate base.* Six microphones are usually employed in the deliberate base; each microphone must be located to an accuracy of 1 : 3,000. Corrected locations of targets are reported and followed by sound ranging adjustment when requested. With a six microphone base, hostile artillery can be located to distances of approximately 20,000 meters. The actual distance is dependent upon the intensity of the sound. Under good sound ranging conditions, locations can be made with accuracies of 50 to 150 meters; however, this accuracy is impaired by high winds. The width of the area of coverage is approximately 10,000 meters. Accuracies are assigned to each location by the sound platoon and should be considered in evaluating the location. From 6 to 8 hours are required to install a deliberate sound base.

(2) *Hasty base.* When time is not available for installing a deliberate sound base, one of the hasty methods described in FM 6–122 will be used. A hasty base contains four microphones which are installed without benefit of survey. They can be map spotted. Since the sound base is not on a common grid with friendly artillery, corrected locations cannot be reported. However, this type base can accurately adjust friendly fire on hostile batteries. The width of the area of coverage is approximately 6,000 meters. A hasty base can be installed in 1 to 2 hours.

Section IV. AERIAL

42. General

Visual ground observation is usually restricted by the next hill mass. Defilade makes it difficult to locate enemy weapons. Aerial target acquisition systems are used to search areas defiladed from ground observation and to increase the depth of observation. The depth into the enemy area to which army aviation can penetrate depends on the characteristics of available aircraft and the enemy air defenses. Technical characteristics of aerial systems and aircraft are discussed in detail in section V, appendix V.

43. Visual Airborne Target Location System (VATLS)

This system consists of one set of ground tracking and support equipment and two sets of airborne equipment. Each set of air-

borne equipment is mounted in an aircraft organic to the aviation section of headquarters and headquarters battery division artillery, infantry, armored, mechanized, or airborne division. The ground tracking equipment is located in the target acquisition platoon of the same unit. The target acquisition platoon commander employs the system under the direction of the division artillery, S2. Because the ground tracking equipment requires line of sight to the aircraft, this equipment is normally employed well forward, and usually within the perimeter of an artillery battalion for security and communications.

44. Manned Aircraft

a. General. Army observation aircraft, depending on type, have the capability to perform day and night visual, photographic, radar, and infrared missions. The particular aircraft to be employed for target acquisition missions is determined by the capabilities and limitations of available aircraft and their sensory devices.

b. Rotary Wing Aircraft.

(1) Rotary wing aircraft have certain characteristics which make them particularly suitable as observation aircraft:

(*a*) Can ascend and descend at a relatively steep angle and operate from confined and unimproved areas.

(*b*) Are capable of horizontal flight in any direction.

(*c*) Can operate at hover or to maximum rated speed.

(*d*) Can fly safely at low altitudes, using the terrain and vegetation for cover and concealment.

(*e*) Have a slow forward speed and near vertical landing ability, which enable them to operate under marginal weather conditions.

(2) The load-carrying capacity of the light observation helicopter precludes the mounting of heavy electronic sensor devices, thus limiting its sensor devices to an aerial observer and/or a camera.

c. Fixed Wing Aircraft.

(1) Army fixed wing aircraft employed in the target acquisition role are medium observation aircraft. Army fixed wing aircraft have capabilities which make them suitable for target acquisition missions not within the capability of light observation helicopters:

(*a*) They have greater range and require less maintenance than helicopters.

(*b*) They can transport relatively large internal and external loads.

(2) Fixed wing aircraft are employed primarily as special

mission aircraft to carry sensor devices not within the capability of observation helicopters.

45. Unmanned Aircraft

Drones as employed by artillery perform day and night photographic target acquisition missions. They are particularly valuable because they can be flown over enemy territory without risk to valuable, highly trained personnel and expensive, complex, manned aircraft. The element of surprise made possible by the small size, speed, and maneuverability of the drone makes the drone difficult to detect and attack and contributes to its effectiveness as a target acquisition equipment platform. Drone systems may be employed in both mobile and static warfare.

a. Organization. One drone platoon, containing drones, tracking radar, and photographic processing equipment, is organic to the headquarters battery of the corps field artillery target acquisition battalion (FATAB). Drone sections are also organic to the aerial surveillance platoons of the aviation company of the armored cavalry regiment and of the aviation general support company of the divisions aviation battalion. The drone platoon is completely mobile and can operate 24 hours a day.

b. Missions. As with weapons systems, the mission, terrain, weather, tactical situation, and the commander's desires dictate the employment of the target acquisition drone. Normally the drone is not employed by the artillery as a general surveillance device, but is flown on specific target acquisition missions for verifying suspect target locations. The map coordinates of the target's location are then determined by restitution from the photographs obtained from the drone flight. A typical drone mission is shown on the map in figure 5. This mission had the road junction (fig. 5) as its target. Based on requirements of the supported force, missions for the field artillery target acquisition drone platoons are normally assigned by corps artillery S2. Drone missions may be either preplanned or immediate.

(1) *Preplanned missions.* For a preplanned mission, requests for target locations are made by higher, lower, and adjacent units and by staff sections. The orders/requests are submitted daily, either to the corps artillery S2 or division artillery S2, for coordination and integration into the corps artillery target acquisition plan which is an annex to the operations order. Mission priorities are the responsibilities of the artillery S2 in coordination with the force G2 and artillery S3. The missions are assigned to FATAB which exercises command and operational control of the drone platoon.

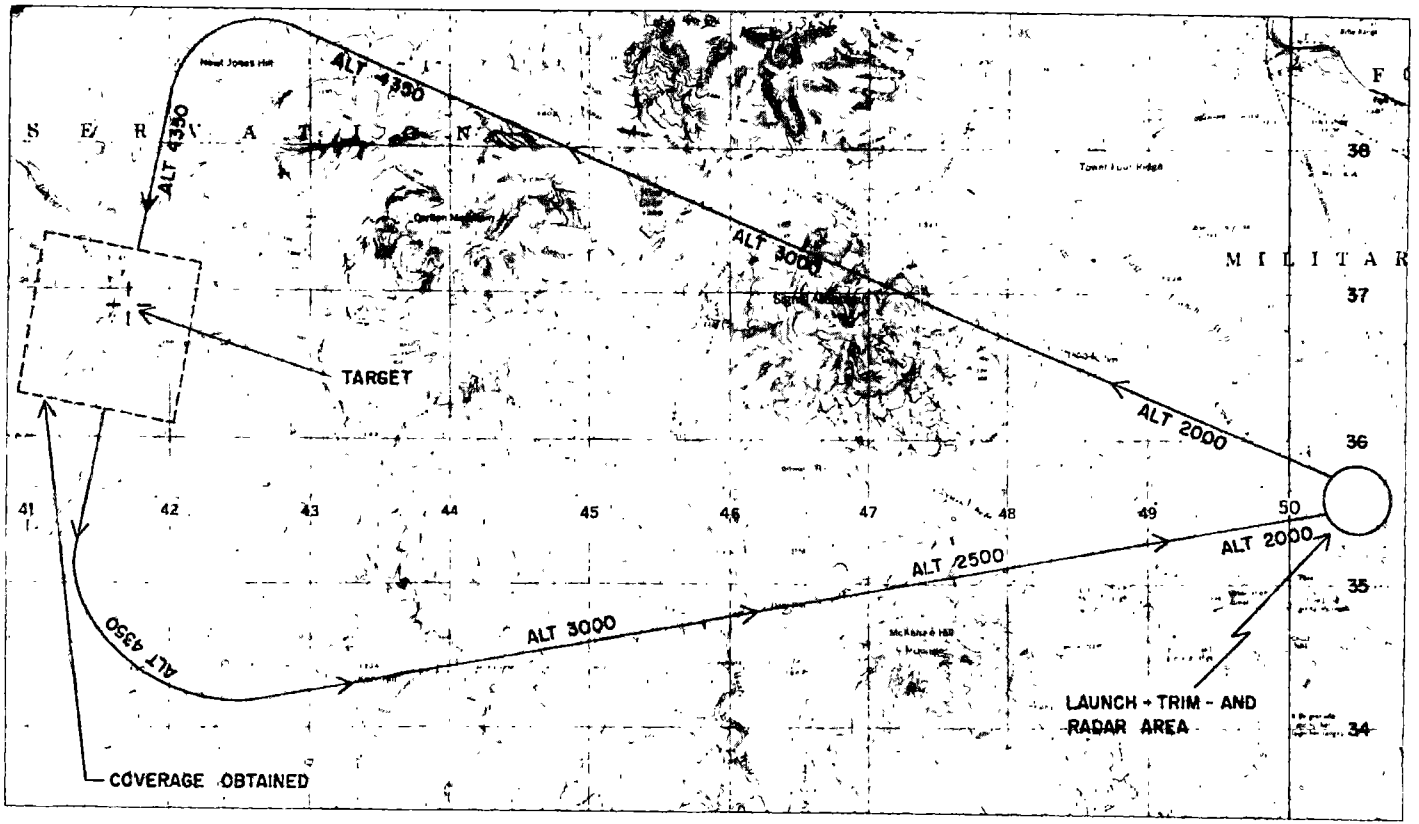

Figure 5. A typical drone mission.

Figure 6. This aerial photograph reveals the target of the mission in figure 5.

(2) *Immediate mission.* An immediate mission request may be submitted at any time through artillery channels to the corps artillery S2 at the artillery fire direction center. Mission requests are coordinated with the S3 and are then assigned to FATAB which exercises command and operational control of the drone platoon.

(3) *Mission planning.* The accuracy and thoroughness of premission planning and the degree of command coordination are major factors that determine the ultimate success of drone target acquisition missions. Drone flights require two types of information to insure a successful flight—semipermanent information (such as weather and flight limitations) that remains in effect for a period of time and mission type information that pertains to that particular mission. Both types of information are provided to the drone platoon commander through the FATAB S3 by the corps artillery S2.

(*a*) Semipermanent type information consists of:

1. Weather conditions over the target area.

2. Flight limitations.

(a) Assigned flight altitudes.

(b) Assigned flight corridors.

(c) Assigned line crossing area.

(d) Drone no-flight areas.

(*b*) Mission type information consists of:

1. Target location.

2. Target description.

3. Flight priority or time.

4. Photo scale required or size of area to be covered.

c. Tactical Employment. To minimize reaction time, all drone ground operations should occur within the same general area. This area is called the drone area and is generally circular in configuration with a 1-kilometer radius (fig. 7). To exploit the maximum effective range of the drone, the entire area should be as far forward as possible with the drone launch and radar position nearest the forward edge of the battle area (FEBA). Drone recovery is accomplished near the photographic and imagery processing location to facilitate rapid transfer of the camera and film from the drone to the photo processing unit.

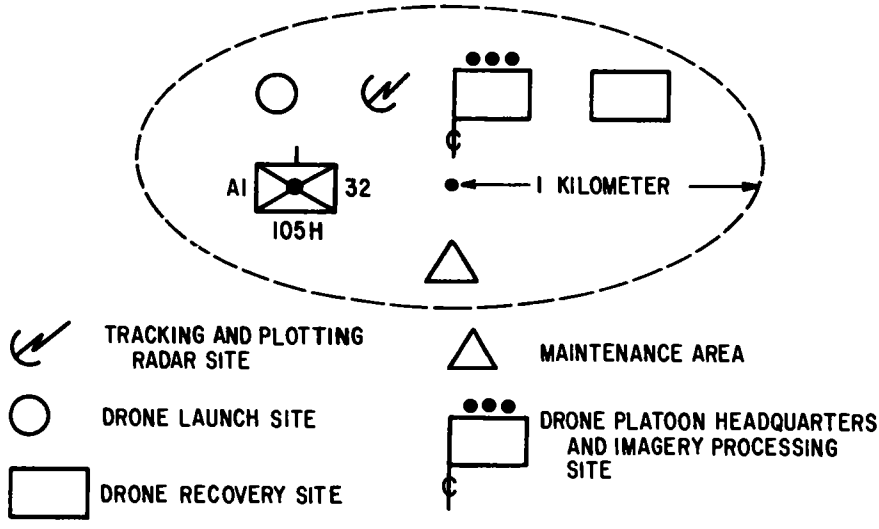

Figure 7. A representative drone area.

Section V. AIRBORNE SENSORS

46. General

There are three types of airborne sensors which may be employed for field artillery target acquisition. These devices are organic to the aviation elements immediately responsive to the needs of the artillery.

47. Airborne Cameras

a. Various aerial cameras with day/night capability are carried in army and air force manned or unmanned aircraft. These cameras provide imagery in 70-mm, 4½ x 4½ inch format and 9½ x 9½ inch format. Technical characteristics of aerial cameras are discussed in detail in section V, appendix V.

b. Optical imagery obtained from aerial cameras produces a permanent record of the area observed. A study of aerial photography discloses recent enemy construction, digging, movement, and other activity not discernible to other available agencies of observation. Targets are identified by their size, shape, shadow and tones. They are transposed to maps and firing charts by techniques explained in appendix IV.

48. Airborne Radar

a. Airborne radar, principally side looking airborne radar (SLAR), produces general intelligence records of terrain presentations and/or indications of moving vehicles. The use of radar imagery for direct target acquisition is limited. Radar imagery is the image of a radar scope photographed on ordinary film. Terrain presentation imagery is used to make small scale mosaics; land masses, streams and water bodies are readily distinguishable. Moving target indications reveal densities of activity and traffic patterns. Airborne radar provide acceptable imagery during periods of daylight or darkness and in conditions of light rain, smoke, haze and dust. Radar may be detected and jammed or spoofed.

b. An image interpreter trained in the techniques of extracting information from radar imagery is required for interpretation of airborne radar imagery. The agency requesting radar imagery must advise the interpreter of the intelligence requirements for each mission in order to permit rapid detection and dissemination of desired information from the radar imagery.

49. Airborne Infrared

a. Airborne passive infrared sensors are carried by medium observation aircraft. These sensors provide an oscilloscope pre-

sentation in the aircraft for immediate viewing by an observer, or by means of a data-link simultaneously provide a display at a ground terminus. The infrared sensor system provides the capability, both in the aircraft and at the ground terminus, of photographing the oscilloscope displays in order to provide both detailed and general record imagery.

b. This imagery provides valuable indications of enemy activities. Therefore, information obtained from infrared imagery must be correlated by target acquisition means which can provide target identification and three-dimensional location in sufficient detail and accuracy to permit effective attack by artillery fire.

c. Airborne passive infrared sensors provides surveillance over large areas rapidly but are limited to line of sight coverage. These devices are invulnerable to electronic countermeasures but are susceptible to spoofing by heat producing devices. Rain, hail, smoke, dust, and fog reduce infrared sensor effectiveness. These sensors may be used in daylight operations but effectiveness is greatly reduced. Tests indicate that these sensors are most effective when employed on clear dark nights.

d. As with radar imagery, a specialist trained in the techniques of extracting information from infrared imagery is required. The agency requesting infrared imagery must submit sufficient data on the requirements for specific information desired to permit the image interpreter to properly analyze the infrared imagery obtained.

CHAPTER 3

TARGET ACQUISITION PLANNING AND COORDINATION

50. General

a. Target information is collected by continuous planning and systematic direction of the collection efforts. Effective utilization of the sources and agencies available for the collection of target information depends on the artillery S2 having a knowledge of their capabilities and limitations. In the course of target acquisition, much intelligence information is gathered. This information is passed on by the artillery S2 to the supported force S2 (G2) without delay. Emphasis is placed on the rapid free flow of information between these two agencies.

b. Target acquisition devices serve the force commander by giving him a 24-hour, all-weather target acquisition capability; increased accuracy of range and azimuth determinations; and increased ability to observe beyond enemy lines.

c. Full exploitation of artillery firepower available to the commander depends on the number and type of target acquisition devices available and the manner in which they are employed.

51. Planning

a. In the initial stages of target acquisition planning, some portions of the plan may be based on assumptions concerning our own forces and the capabilities of the enemy. As additional information becomes available, changes are made to conform to the actual situation. These changes will require corresponding changes in the plan as it is being evolved. The required flexibility must be insured by simplicity of procedures in disseminating information and by coordination among all of the staff sections engaged in the planning. The final plan must be flexible to accommodate changes in the friendly or enemy situation as they develop.

b. Higher echelons are responsible for providing information and instructions to subordinate units at the earliest possible time by means of briefings, orders, and directives. At successive echelons, the plan is expanded to include the details required for

that particular echelon. Coordination between senior and subordinate echelons through conferences and visits during the planning stage insures that no problems are overlooked and that solutions are determined promptly.

c. The artillery S2, after making a study of the collection worksheet, observation plans, patrol plans, and the intelligence estimate evaluates the suspect target areas and establish priorities of observation. The S2 then compares the requirements with the capabilities and issues appropriate requests to subordinate target acquisition units and to higher headquarters. Upon receipt of the capabilities charts from assigned and subordinate units, the S2 prepares a consolidated capabilities chart. Analyses of this chart indicates any coordination necessary to insure maximum coverage of the area of operation. In the target acquisition battalion the S3 is the principle staff officer for coordination of the target acquisition effort, rather than the S2. The FATAB S3 assigns general areas of operation to the batteries, based upon requests for information issued by the corps artillery S2. The FATAB S3 designates priorities for specific suspect areas to the batteries for primary and contingent zones of observation. The S3 consolidates the battery capabilities charts into a battalion capabilities chart, and forwards copies to corps artillery and the supported units.

d. Early in the planning stage of an operation, a list containing suspect target areas and potential targets suitable for nuclear attack is developed. Such factors as the mission, enemy intelligence, characteristics of the area of operation, and enemy tactics and practices are studied to select probable target areas. The collection effort insures a systematic day-and-night, all-weather observation to detect potential targets. Areas of particular importance to operational plans are subjected to intensive observation.

e. The collection effort is then directed toward securing information to verify, identify, locate accurately, or disprove the presence of suspected targets by target acquisition means. This is accomplished by assigning suitable tasks to the various collection agencies. Expanded frontages and depths will require intensified planning and maximum use of available target acquisition devices.

f. Each subordinate unit involved in the operation prepares its own plan, based upon the plan of operation. All target acquisition means are integrated to provide a complete coverage of the commander's area of influence.

g. When orders and requests for specific information are assigned, the capabilities of the target acquisition means available to the collection agencies are considered. For example, the ground

surveillance radar section cannot be asked to locate a stationary target.

b. Target acquisition capability overlays (app. I) are submitted by all target acquisition agencies. Without these plans coordination of the collection effort is handicapped. For example, without the target acquisition plans and overlays of subordinate units, gaps in the target acquisition coverage of the corps or division area may not be detected.

52. Coordination

a. The collection worksheet, observation plans, air reconnaissance plans, and patrol plans facilitate the coordination of the target acquisition effort. To insure timeliness in target acquisition for the employment of nuclear weapons, subordinate commands may be required to report information directly to the tactical operations center. This direct reporting is limited to specified items of information.

b. The target acquisition plan and instructions for coordination of the target acquisition effort may be issued orally, in written fragmentary form in the force operation order, in the intelligence annex, or as an appendix to the intelligence annex. For an example of a corps target acquisition plan, see appendix I.

53. Direct Support Battalion

a. After receiving information of the enemy and recommendations from the division artillery S2, the direct support battalion commander selects the general position area in which the countermortar radar is to be employed. This area should be large enough to enable the radar officer to select the actual radar position, based on technical considerations affecting the operation of the radar. In addition the battalion S2 designates the sector of search for the radar if not previously designated by higher authority. This sector of search will normally coincide with the zone of action of the supported unit.

b. Prior to occupying the OP's or joining his assigned infantry (tank) company the FO receives any special instructions that the S2 may have such as particular areas to keep under surveillance and what is suspected of being in this area. Forward observers (FO's) select their OP's in the zone designated by the appropriate artillery liaison officer with the supported unit. This is done to insure observation within the zone of action of the supported unit. Forward observers will prepare visibility diagrams for their OP and submit these to the liaison officer for forwarding to the battalion S–2.

c. Upon receiving the visibility diagrams from the forward

observers and the surveyed location and position evaluation charts of the radar, the battalion S2 prepares a battalion target acquisition capabilities chart consisting of consolidated visibility diagrams of the OP's and a position evaluation chart of the countermortar (app. I). One copy is forwarded to the division artillery S2 for integration into the division artillery capabilities chart.

54. Division Artillery

a. Based on division level requirements provided by the division G2, the division artillery S2 determines the location of suspect areas and decides which devices are most appropriate for providing surveillance of each of the suspect areas. Continuous coordinaton with the division G2 in the determination of priorities of effort is essential. He then issues proper instructions to the direct support battalion S2's and to the target acquisition platoon of the headquarters battery, division artillery. These instructions includes recommending the general position areas for the countermortar radars and instructions for the employment of the visual airborne target location system (VATLS) and surveillance radar.

b. The division artillery target acquisition platoon prepares a position evaluation chart for the surveillance radar and forwards one copy to the division artillery S2. The division artillery S2 then consolidates the position evaluation and visibility charts from the direct support battalions and the division artillery target acquisition platoon. One copy of this consolidated capability chart is forwarded to the corps artillery S2. (app. I).

55. Corps Artillery

a. After making a study of the collection worksheet, observation plans, air reconnaissance plans, and patrol plans the corps artillery S2 determines the number and location of suspect target areas and the priority of the areas in which targets are suspected. He then balances the requirements with the capabilities and makes appropriate allocations at the briefing of the division artillery S2's and the field artillery target acquisition battalion S3. The corps artillery S2 consolidates the capabilities charts submitted by these organizations into a corps artillery capabilities chart (app. I). A study of this chart indicates any changes necessary to insure complete coverage of the corps front.

b. After the briefing by the corps artillery S2, the FATAB S3 assigns general areas of operation to the target acquisition batteries. He also designates specific suspect areas on which to concentrate to locate enemy targets. The batteries are required to submit capabilities charts with visibility charts from the flash platoons. The FATAB S3 maintains a battalion capabilities chart

with one copy being forwarded to the corps artillery S2. The FATAB operations and intelligence section acts as a correlating center for all target locations and target information produced by agencies within the battalion.

56. Army Artillery

At all levels of command it is very important that there be close liaison between the artillery (S2) and the supported force (S2). This is particularly true at army level. Much of the information used by the army artillery S2 in developing suspect target area locations is provided by the army G2.

CHAPTER 4

ARTILLERY INTELLIGENCE

Section I. COLLECTION OF TARGET INFORMATION

57. General

Artillery intelligence is knowledge acquired through the collection, processing, and dissemination of all information pertaining to potential or actual targets. Target acquisition agencies are primarily concerned with timely recognition, accurate determination of characteristics, and prompt reporting of the location of targets whose destruction or neutralization will assist the supported unit in accomplishing its mission. Target acquisition agencies are also concerned with observation of targets both before and after their attack by fire to collect and report all information of military significance.

58. Information

The target acquisition devices available to the commander provide a means of obtaining accurate and timely hostile target locations. These devices must be efficiently and aggressively employed to take full advantage of their inherent capabilities. When fully supported by rapid survey and adequate communications, target locations may be accurately located, the locations quickly transmitted, processed with minimum delay, and the necessary counterbattery action initiated.

59. Radar Locations

Radar is effective in collecting target information of hostile mortar and artillery activities with considerable accuracy, during daylight and darkness. It is not seriously affected by adverse weather conditions and it can play a decisive role in neutralizing the enemy's artillery capability. Hostile weapon locations data are quickly processed within the radar system. Because the target is active when a radar location is made, data is provided to initiate immediate counterbattery fire. The target data obtained from radar locations is used by the artillery S2 and CBIO in their

processing of target information and in developing the general target overlay (fig. 8, flow chart).

60. Sound and Flash Ranging

Locations made by sound and flash ranging platoons may be considered accurate and reliable. When employed to supplement each other, sound and flash bases provide good battlefield coverage of the area immediately forward of FEBA to a depth of approximately 20 km. The information is collected as soon as the hostile artillery becomes active and the necessary processing to obtain both target information and intelligence data are quickly performed within the sound or flash platoon. Like radar locations, to be utilized most effectively, sound and flash locations should be immediately provided to firing units so that counterbattery action may be taken while the targets are still active. The target information collected is also utilized by the artillery S2 or CBIO in developing the general target overlay (fig. 8, flow chart).

61. Target Acquisition Drone System

The target acquisition drone system can collect a great volume of target information. Since this system locates targets prior to the time they become active and without regard to defilade it can verify suspect targets or generate new suspect locations. Once a suspect location has been verified by the image interpreter at the processing location the target information is immediately transmitted through appropriate channels to the agency concerned. This target information must be sent electrically and not be delayed or slowed to the rate of transmission of the photo copies. Copies of photography will normally be furnished the corps artillery S2 or requesting agency only upon special request.

62. General Surveillance

The general surveillance of the battle area provided by FATAB and other target acquisition agencies contribute to the total artillery intelligence collection effort. Listening posts, flash OP's, sound OP's, and surveillance radar installations are continuously active in reporting all enemy movement or activities. The information obtained may be considered to be reliable and accurate when reported by trained observers. When full advantage is made of the communications organic to these agencies these reports are timely.

Figure 8. Artillery data flow (Target Acquisition Battery Attached).
(Located in back of manual)

Figure 9. Corps artillery data flow chart (FATAB in support of Corps Arty).
(Located in back of manual)

Section II. PROCESSING TARGET INFORMATION

63. General

Field artillery target acquisition procedures do not always follow the accepted techniques of processing, recording, evaluation, and interpretation which apply to intelligence procedures in general. In some instances, especially when the target acquisition device operates from forward areas, the complete process occurs within seconds. For example, the processing may involve no more than reading the coordinate location from dials on the computer, the recording may be accomplished while the information is being transmitted to the firing unit, and the evaluation and interpretation may be accomplished with little formality or waste of time by the firing unit. In this way, artillery fire is placed on the target before the enemy has time to react. In other cases, the complete processing cycle is accomplished by intelligence personnel prior to transmission of the information to the G3 (S3) for action.

64. Processing

Processing is the means by which information is transformed into intelligence. (A complete discussion of the intelligence process is found in FM 30–5.) The sequence that applies to processing information into combat intelligence applies also to processing information into artillery intelligence. The three basic elements of processing are recording, evaluation and interpretation. The evaluation and interpretation of target information is facilitated by recording and plotting the information on appropriate forms, records, and charts. These charts and records used in counterbattery intelligence activities are explained in appendix II.

65. Recording

Recording is the systematic arrangement of information to facilitate its processing into intelligence. The recording function supports evaluation and interpretation which are the decisive actions. Unless information is recorded quickly and economically, timely evaluation and interpretation may not be possible. The procedures used in recording should be simple yet adequate to handle the volume of information received. The records used for general target information are:

a. The S2 journal, a chronological record of events affecting the S2 section. The format and method of recording is as prescribed for a staff section journal (FM 101–5).

b. The S2 situation map, a map or photomap of a suitable scale covered with an overlay on which are posted friendly and enemy frontlines, division and corps boundaries, and all available

information of the enemy. The map is used for planning harassing and interdiction fires and for developing fire plans to support an attack or defense. Fire plans should be checked against this map and against hostile weapons charts and associated overlays at division and corps levels to insure that all appropriate targets are attacked.

c. The general target overlay, an overlay, used in conjunction with the S2 situation map, on which are plotted all enemy locations determined to be targets.

d. The general target file, a file in which a card is kept for each target located, with the exception of counterbattery locations. The complete history of the target is recorded on this card. This file enables the S2 to correlate reports of enemy activity at a given location. The target file card is also useful in the examination of overrun positions to determine the effectiveness of friendly fires and discern enemy tactics and techniques of employment. The hostile battery file (mortar) card (DA Form 2186–R) (fig. 10) or a similar card may be used for this purpose. This form may be reproduced locally on 10½ x 8-inch cards.

e. The CBIO maintains certain forms and records which assist him in performing counterbattery functions. These forms and records, which are listed in (1) through (7) below, are discussed in detail in appendix II.

(1) The artillery counterfire information form (ACIF).
(2) The counterbattery intelligence map.
(3) The hostile weapons chart.
(4) The suspect location overlay.
(5) The shelling report (SHELREP) overlay.
(6) The roving gun location overlay.
(7) The hostile battery file (mortar).

f. In the field artillery target acquisition battalion all target locations obtained by sound, flash, radar, and drones are recorded on (DA Form 6–6) (fig. 11).

66. Evaluation

Evaluation is defined as the appraisal of an item of information to determine its pertinence, reliability, and accuracy.

a. Pertinence. Immediately after its receipt by the S2, information is examined to determine its relevancy and value. Is it information of the enemy or of the characteristics of the area of opeartions? Is it information of value to the unit or to higher, lower, or adjacent units? Is it needed immediately and, if so, by whom? Is it of future value? These questions should be answered in estimating the pertinence of the information.

b. Reliability. The reliability of the source and the collecting

(X)HB ( )HM ( )HR LISTED ON	120 LIST NUMBER	50 EVALUATED ACCURACY	5929 SQUARE	(X)HB ( )HM ( )HR AFC LETTER DESIGNATION

HOSTILE BATTERY LOCATION (MORTAR)							OUT COUNTERBATTERY FIRE (COUNTERMORTAR)					
REF	COORDINATES*	ALT	TARGET DESCRIPTION	ACCU-RACY	SOURCE	DATE	DATE/ HOUR	OBSVD BY**	FIRED BY	CONC NO	NO RDS	EFFECT
1R 107	59468935	130	4/?/?/	50	PI	16 1100						
113	59302933	137	4/?/?	100	FR	16 1330						
115			2/120/m		2(G)	16 1450						
117	59702986	138	4/?/m	50	AOP	16 1545	16 1545	AOP	OBSR	AFC	36	NEUT

*Adjustsd coordinates may be augmented by coordinatss from photo inspection.
**Give unit and type of obsservation and if fired from photo.
HB - Hostile Battsry HM - Hostils Mortar HR - Hostils Rocket

HOSTILE BATTERY FILE (MORTAR) (FM 6-121)

DA Form 2186-R, 1 Jul 62 Previous edition is obsolete.

Figure 10. Hostile Battery File (Mortar) Card (DA Form 2186-R).

RECORD OF SOUND, FLASH, AND RADAR LOCATIONS
(FM 6-121)

PERIOD COVERED:	FROM TIME	FROM DATE	TO TIME	TO DATE	SHEET NUMBER	NUMBER OF SHEETS

L	M				N	O	P	Q	R	S	T	U
FROM (Plto Ar)	GRID REFERENCE AND HEIGHT		ACCURACY		MEANS OF LOCATING	TIMES ACTIVE (From - To)	NATURE OF TARGET	REMARKS (Area Shelled, Etc.)	TIME REPORTED TO BATTY CP	MISSION FIRED BY	NUMBER OF ROUNDS	CONC. NR
	E AND N	H	METERS	NR PLOTS								

DA FORM 1 SEP 55 6-6 EDITION OF 1 OCT 53 WILL BE USED UNTIL EXHAUSTED

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Figure 11. Record of Sound, Flash, and Radar Locations (DA Form 6-6).

agency must be examined before the information can be evaluated. To what extent is the source or agency accurate and reliable? Has the agency sufficient training, experience, and ability to report accurately the information in question? Could the information actually have been obtained under conditions existing at the time (time and space, means employed, visibility, etc.) ? These questions should be answered in estimating reliability of the source and the collecting agency.

c. Accuracy. The accuracy of the information must be examined separately from the reliability of the source of collecting agency. Is the purported fact or event at all possible? Does it agree or disagree with known facts? Can the information be confirmed or corroborated by a different source or agency? If the information is at variance with other information and the conflicting items cannot be reconciled, which information is more likely to be correct? These questions should be answered in estimating the accuracy of each item of information.

67. Interpretation

Interpretation is the final step in the processing sequence. The evaluated information is analyzed to determine its significance with respect to information or intelligence on hand, and conclusions are drawn therefrom. Correct interpretation will lead to accurate conclusions concerning target information. Proper interpretation of target information is essential to the employment of effective fire support. Interpretation of target information is particularly significant when nuclear fire is contemplated or employed.

Section III. IMAGERY

68. General

a. Imagery includes the graphical representation of terrain and may be portrayed as a photograph, infrared image, radar image, or scope portrayal. Three types of imagery are of importance to artillery target acquisition:

(1) *Radar permanent echo strip map imagery.* Imagery provides information of the topography of the area being observed as well as cultural features such as roads, railroads, airfields, built-up areas, etc. The moving target feature provides important data on the movement of objects in the area being viewed. By comparing fixed object and moving target displays, the interpreter can determine the general type of traffic observed. Imagery obtained from current aerial radar equipment does not permit identification of the type, direction or speed of

movement, or of the quantity of vehicles, railroad cars etc.; however, with two consecutive runs, comparison may determine direction and velocity of movement. Radar imagery may be portrayed on 4 by 5 inch cut film or on 70-mm roll film.

(2) *Infrared imagery.* Infrared imagery is portrayed on photographic film strip and displays "hot" ground objects and terrain. "Hot" objects are those objects which emit infrared radiations. Variations in the temperature of objects and terrain produce the terrain imagery. Proper interpretation is dependent upon the interpreter's knowledge of the relationship between what has been viewed by the sensor and what appears on the recording.

(3) *Photography.* Photographic imagery is portrayed as still pictures singly or in series, each picture representing a single exposure of the camera film. They are true black and white photographic prints and depict the terrain and all visible objects as it appeared at the time of exposure. Comparison of photos taken at different times will disclose changes in location, or addition of material objects.

69. Interpretation

Image interpreters are required for interpretation of conventional photography, infrared, and radar imagery. They are supplied by the military intelligence units attached to corps, divisions, and armored cavalry regiments.

70. Requests for Imagery

Requests for imagery are normally routed through the G2/S2 Air and must include the following information:

a. Area to be covered.

b. Specific information desired.

c. Prominent terrain features to be included for use as control points in interpretation.

d. Any special instruction for interpreters in the case of radar and infrared imagery.

Section IV. DISSEMINATION AND USE OF ARTILLERY INTELLIGENCE

71. General

The artillery intelligence cycle is culminated when artillery intelligence is disseminated and put to use. Since artillery intelligence is a part of combat intelligence, the artillery intelligence must be forwarded promptly to the appropriate G2.

72. Dissemination

Disseminated information should be pertinent, concise, clear, accurate, and timely. The recipient should not be burdened with unnecessary or irrelevant details or with illogically presented information.

a. Artillery intelligence is disseminated by the most suitable means available; e.g., radio, wire, written messages, conferences, or intelligence documents. Artillery communication channels are normally utilized for the transmission of artillery intelligence.

b. Representatives of fire support agencies and of the supported unit transmit all available information to their parent units.

73. Intelligence Documents

The intelligence documents commonly used for disseminating combat intelligence and information are discussed in FM 30–5. Target information may also be disseminated by the following means:

a. Hostile Battery, Mortar, and Flak Lists. Lists of hostile locations are compiled for all interested agencies. Confirmed and suspect locations are listed separately. The lists are numbered, dated, and published at the direction of the appropriate commander and are kept current by the publication of additions, deletions, or changes in paragraph 5 of the artillery intelligence bulletin or in annexes to the periodic intelligence report of the supported force.

b. Artillery Intelligence and Information Bulletins. Artillery intelligence bulletins may be published at the direction of the corps artillery and division artillery commanders. Artillery information bulletins are published by the artillery commander (officer) at army or theater army levels.

c. Target Summaries. Target summaries consist of hostile battery, mortar and flak lists and general target locations compiled from latest available information. Complete target summaries are numbered, dated, and published at the direction of the appropriate commander. They are kept up to date by the publication of additions, deletions, and changes in paragraph 5 of the artillery intelligence bulletin or in annexes to the periodic intelligence report of the supported force. The target summary may indicate a recommended priority for each target.

d. Artillery Periodic Intelligence Report. The artillery periodic intelligence reports (corps and army artillery only) summarize information concerning the enemy capabilities, situation, and operations and the weather and terrain. A separate artillery periodic intelligence report may be prepared, or the information normally included therein may be incorporated in the periodic intelligence

report of the supported force. The period of time to be covered in the report is specified by higher headquarters or by the appropriate commander in the absence of instructions. Normally, the report covers a 24-hour period.

74. Use of Artillery Intelligence

a. Force G2. The force G2 uses artillery intelligence in connection with intelligence from other sources to determine the enemy's capabilities and courses of action, and the relative probability of the enemy's adopting the various courses of action of which he is capable. Which, when analyzed with respect to other information, assist the force G2 in making these determinations.

b. Artillery Use. Artillery intelligence is used—

(1) To assist in the destruction or neutralization of located targets.
(2) As a factor in the allocation of artillery to lower echelons.
(3) As a factor in requesting additional artillery from higher headquarters.
(4) To assist the commander in the disposition of friendly artillery and in determining the organization for combat.
(5) As a vital consideration, along with the mission of the force, in determining the available supply rate of ammunition for subordinate artillery echelons.
(6) To assist commanders in determining the required supply rate to be requested from higher headquarters for planned operations.
(7) In planning future operations.

Section V. TARGET ANALYSIS

75. General

a. Target analysis is the examination of the characteristics of a target to determine its vulnerability or the relative suitability of available weapons systems for its attack. Targets of opportunity, as well as targets for prearranged fires, are analyzed. The length of time and amount of detail involved in making a target analysis depends on the amount of information available concerning the target, the means of attack available, the degree of coordination required, and the urgency for the attack. An analysis may be either a rapid, mental calculation (low echelons) or a detailed and written calculation (division, corps, or army artillery). It assists the commander in delivery of effective fires.

b. Usually, a written analysis will be made only if time permits and it is needed in connection with the use of nuclear weapons or for the detailed staff planning of future operations. The attack

of heavily fortified positions, deliberate river crossings, major amphibious landings, and airborne assaults will usually require a detailed target analysis during the planning phase of the operation.

76. Responsibility of Artillery S2

a. Analysis and Evaluation. Target analysis and target evaluation are functions of intelligence and operations officers, respectively. The artillery S2 is responsible for ascertaining the target characteristics and recommending to the fire support coordinator the relative priority of attack for each target. The principal characteristics to be considered are—

(1) *Nature of the target*
   (*a*) Composition.
   (*b*) Size and shape.
   (*c*) Vulnerability.
   (*d*) Mobility.
   (*e*) Recuperability.

(2) *Location of the target.* The location of the target may indicate or eliminate a particular means of delivery. The proximity of the target to friendly troops, and to enemy installations protected by the Geneva Convention should be considered. The probable accuracy of the target location should be analyzed.

b. Terrain and Weather.

(1) *Terrain.* Terrain in the target area has a direct bearing on the vulnerability of the target. Rugged terrain affords considerable natural cover and makes target location difficult. Targets that are well defiladed by terrain sometimes can only be reached by high-angle fire or by aircraft. Certain terrain provides complete defilade from some angles of approach but not from others, thereby influencing the selection of a means of attack and frequently necessitating the movement of a weapon to a position from which it can deliver effective fire. The nature of the vegetation in the target area should be considered in the selection of ammunition. Information as to the relief, surface soil conditions, and vegetation in the target area is essential when considering nuclear attack. Uneven terrain frequently limits surveillance of fires to aerial observation and in some instances completely prevents observation of fires. Uneven terrain reduces radar coverage, and may reduce the effect of nuclear weapons.

(2) *Weather.* Weather greatly affects the capability of attack by air and to a lesser degree by naval gunfire and ar-

tillery. It is of special importance in evaluating a target for nuclear or chemical attack. Information as to visibility at ground level, cloud cover, and ceiling is a minimum requirement.

(3) *Joint effects.* Terrain and weather jointly affect visibility of the target and may require further study to determine a suitable means and method of attack.

c. Target Capabilities. Target capability is the ability, actual or potential, of a target to influence the accomplishment of the supported unit's mission. An estimate is made as to the time a target can exercise its capability. Target capability is an important consideration in determining the priority assigned to the attack of a target and the weight of fire delivered on a target. The time of attack, the effect desired, and the selection of means to be used are influenced by considering target capabilities.

(1) *Priority for attack.* There is rarely sufficient fire support to attack simultaneously all targets that it may be desirable to engage. Accordingly, the attack of these targets is usually spread over a period of time. On occasion, owing to such factors as ammunition shortage or inadequacy of available delivery means, it may not be possible to attack all known targets. Therefore, it is often desirable to determine the relative priority of targets for attack. Intelligence and operations representatives work together in assigning priorities. Priorities do not necessarily indicate the time of attack or the sequence in which targets will be attacked. The priority assigned a specific target will frequently depend on the echelon assigning the priority and the mission of the supported unit. A top priority target at direct support battalion may have a much lower priority at corps artillery level.

(2) *Priority classification.* As a guide in determining priorities for attack of targets, the following may be used:

(*a*) *Priority I.* Targets capable of preventing the execution of the plan of action.

(*b*) *Priority II.* Targets capable of immediate serious interference with the plan of action.

(*c*) *Priority III.* Targets capable of ultimate serious interference with the execution of the plan of action.

(*d*) *Priority IV.* Targets capable of limited interference with the execution of the plan of action.

d. Reference. A detailed discussion of the joint target analysis, including the responsibilities of the S3, is contained in FM 6–20–2.

APPENDIX I

TYPICAL TARGET ACQUISITION PLAN

1. General

a. The example of a target acquisition plan shown herein is for the guidance of the S2 in preparing the corps artillery portion of the corps observation plan.

b. The corps observation plan, which is prepared by the G2, is an appendix to the intelligence annex. The corps observation plan directs the activities of all corps observation agencies and will include the *artillery target acquisition plan.*

c. The information included in this example may be published as a separate paragraph in the corps observation plan appendix or, if voluminous may be published as a tab to the appendix. The same format may be used by corps artillery to publish a target acquisition plan which is not to become a part of the corps observation plan. In this last instance, the document is formally disseminated to appropriate artillery units with the corps.

(Classification)

(Changes from oral orders, if any)

Copy Nr 7
1st Corps
STENINAU (3374) GERMANY
200600 Aug 19__
X7X

TAB C (Artillery Target Acquisition Plan), to Appendix 2, (Observation Plan) to Annex A (Intelligence) to OPORD 6.
Map: GERMANY, 1 : 50,000, sheets S6, S7, S8.
0–0 LINE. (300100)—(340060)—(380049)—(420023). (See overlay attached.)

2. Zones of Responsibility

a. Corps artillery.

(1) 101st Arty Group: As directed by 1st Inf Div Arty.

(Classification)

(2) 102d Arty Group: Obsn beyond 0–0 line from 22 northing to 34 northing. Coordinate with "B" Btry FATAB.
(3) 103d Arty Group: Obsn beyond 0–0 line from 26 northing to 38 northing. Coordinate with "C" Btry FATAB.
(4) 104th Arty Group: Obsn beyond 0–0 line from 36 northing to 48 northing.

b. Division Artillery: Observation in div Z, south (short of 0–0 line).

3. Ground Observation

a. Observation posts.
(1) Corps artillery: 1st Corps SOP.
(2) Division artillery:
(*a*) As directed by div arty cmdr.
(*b*) Coordinate Lacrosse guidance stations with arty OP's.

b. Capability chart: 1st Corps SOP. To 1st Corps Artillery not later than 21700 Aug 19___.

4. Radar, Sound and Flash

a. Corps artillery.
(1) Special attention to areas indicated on inclosure 1 to tab C (omitted). (When the areas are few in number, list here.)
(2) Radar: As directed by CG, corps arty.
(3) Sound: As directed by CG, corps arty.
(4) Flash: As directed by CG, corps arty.

b. Div arty radar: As directed by div arty cmdr.

5. Air Observation

a. Airfields and heliports.
(1) Corps artillery.
(*a*) Hq, 1st Corps Arty: (321736).
(*b*) Arty groups: Select and report by 21000 Aug 19___. (When known, give location.)
(*c*) Battalion: FA and msl; select and report by 211000 Aug 19___. (When known, give location.)
(d) FATAB: Select drone area and report by 211000 Aug 19___. (When known, give location.)

b. Surveillance schedule.
(1) Corps arty.
(*a*) 101st Arty Group: As directed by 1st Inf Div Arty comd. (This group is reinforcing 1st Inf Div Arty.)

(*b*) 102d Arty Group: Minimum of one aircraft, and observers continually in Z from BMNT—15 minutes to EENT + 30 minutes.

(*c*) 103d Arty Group: Minimum of two aircraft, and observers continually in Z from BMNT—15 minutes to EENT + 30 minutes.

(*d*) 104th Arty Group: Minimum of one aircraft, and observers continually in Z.

(*e*) AO1 Mohawk: As directed by corps artillery S2.

(*f*) FATAB:

1. Immediate: Minimum of one drone always on call.

2. Preplanned: One flight every 12 hours over areas indicated on Inclosure 1 to Tab C (omitted).

(2) Div arty: As directed by div arty comd.

Acknowledge.

Incl: 1—Enemy Artillery

BRAVO
Lt Gen

2—Locations (Omitted)

OFFICIAL:

/s/ Snoop
SNOOP
G2

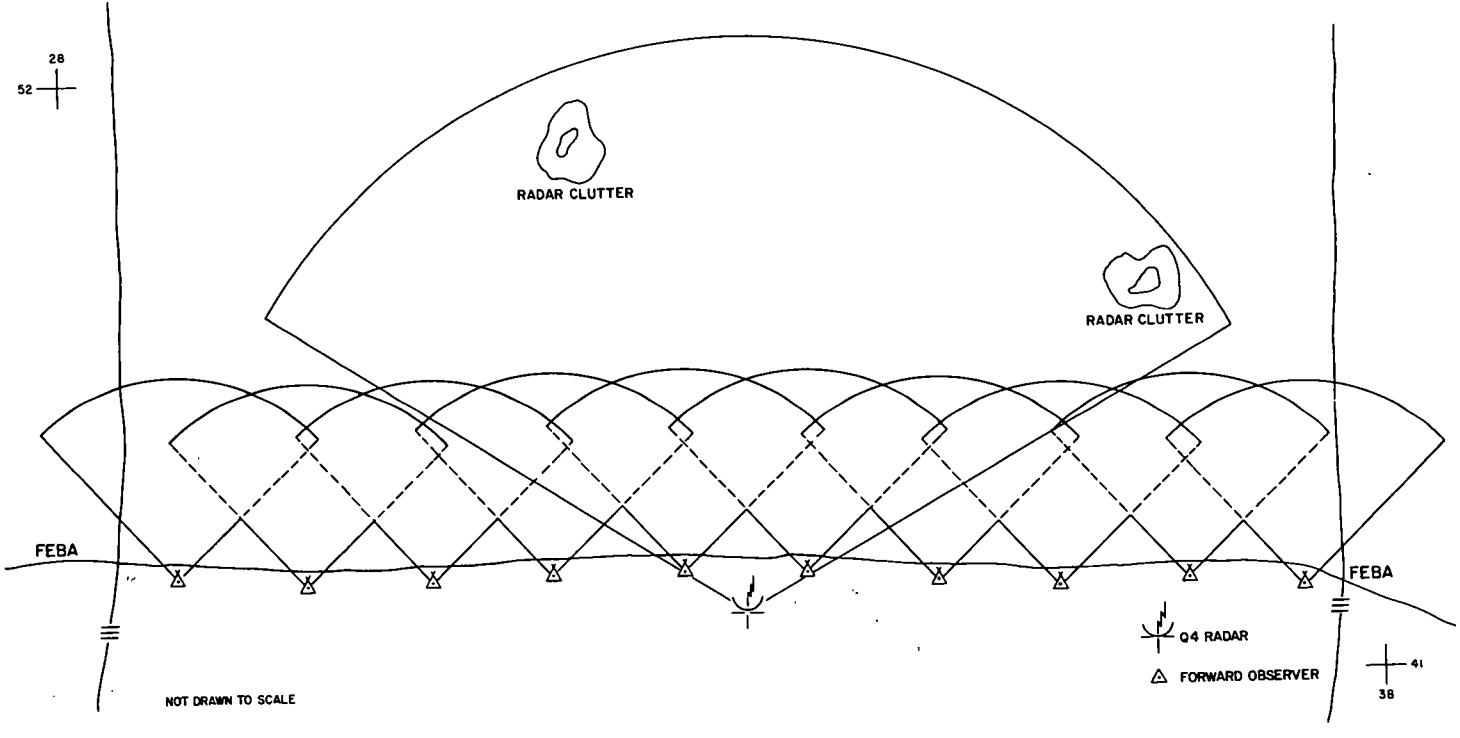


Figure 12. Direct support battalion capability chart.

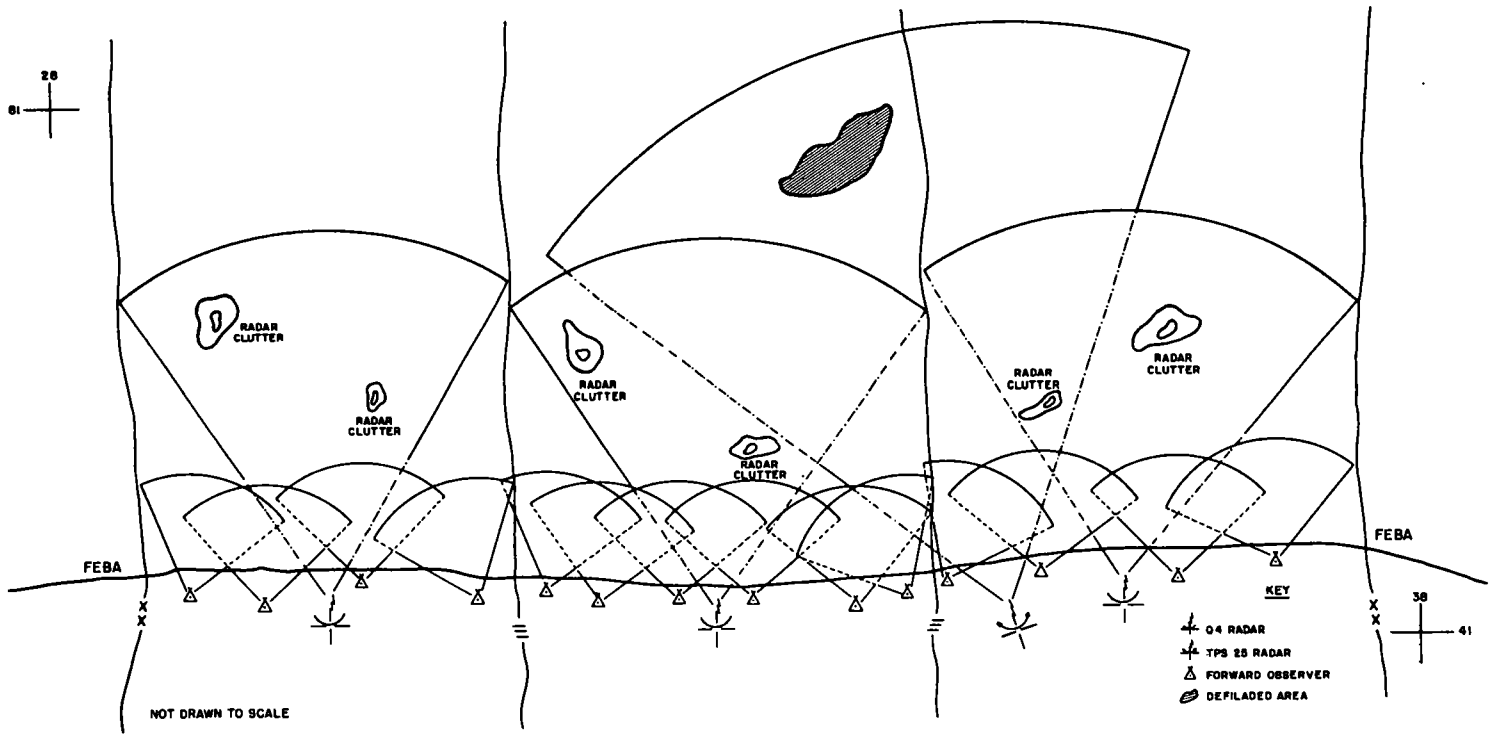


Figure 13. Division artillery capability chart.

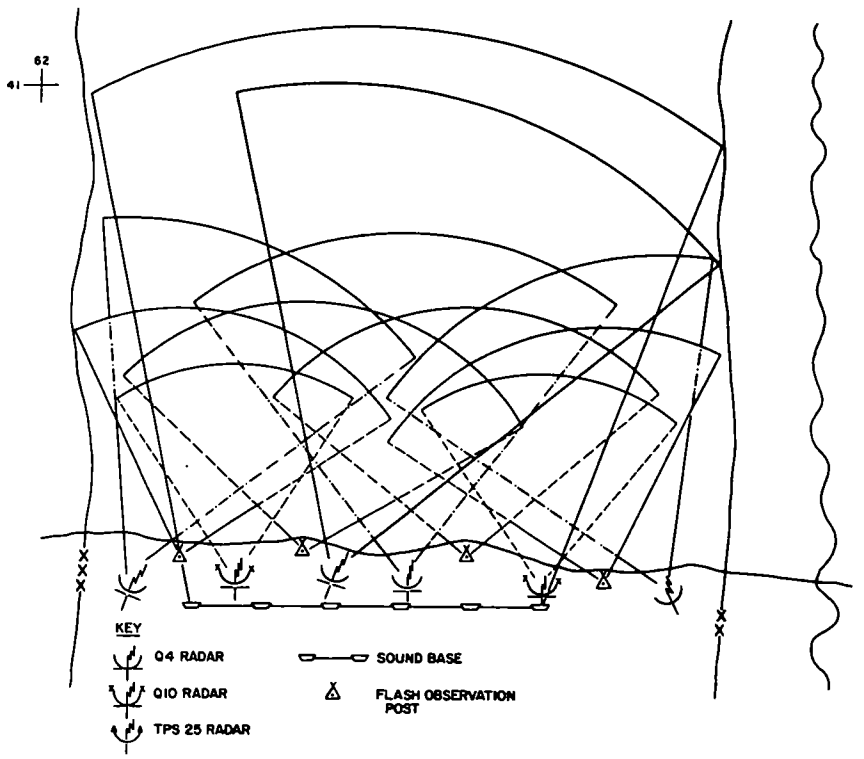


Figure 14. Corps artillery capability chart.

APPENDIX II

COUNTERBATTERY ACTIVITIES

1. General

The term "counterbattery" includes fires on mortars, cannon, rockets, and missiles. Counterbattery intelligence has as its objective the gathering of complete information pertaining to hostile firing means. In this respect counterbattery intelligence is more specialized than other phases of military intelligence. Its immediate operational objective is attained when the fire support agencies are provided with sufficient information to properly engage the hostile weapons with effective fires.

a. Counterbattery intelligence serves a broader function when its product is integrated into the whole of the intelligence effort. Important tactical deductions, independent of the operation of attacking hostile weapons, may be derived from positive knowledge of the enemy artillery strength and dispositions.

b. Successful counterbattery intelligence depends on the aggressive coordinated employment of contributing intelligence agencies and on the systematic recording and evaluation of assembled data.

2. Responsibility

a. A clear line of distinction between the functions of the various programs (i.e., counterbattery, counterflak, etc.) is not always possible or desirable; therefore, responsibility for a particular program is not fixed upon any one artillery echelon, but is based on the premise that the most appropriate means available will be utilized to locate and attack these targets.

b. In discharging this counterbattery responsibility, an artillery commander is assisted by—

(1) The S2, who is concerned with all intelligence.

(2) An assistant S2, counterbattery officer, who produces counterbattery intelligence, to include the location and identification of hostile weapons, the study of enemy tactics and techniques, and the determination of enemy capabilities and limitations.

(3) The S3, who utilizes organic, attached, and reinforcing weapons, for the most effective attack of hostile weapons provided by the S2 and his assistants.

3. Counterbattery Tactics

In many situations it is necessary for the commander responsible for counterbattery operations to outline the counterbattery tactics to be followed. The tactics will be the commander's concept of the employment of his fire support in the counterbattery role. The tactics employed are continually scrutinized and revised as necessary in accordance with the changing situation. The complexity of the considerations involved in determining the tactics requires detailed staff coordination.

a. Definition. The counterbattery tactics is an expression by the artillery commander of his plan for employing the artillery to attack hostile weapons in support of the force commander's mission and plan of maneuver or scheme of defense. It may include the type of counterbattery program to be executed, standard methods of attack of specific targets, and the artillery commander's criteria as to what should constitute a suspect weapon location and what should constitute a confirmed weapon location for the specific tactical situation.

b. Description of Counterbattery Tactics. There are three conditions which describe counterbattery tactics to be employed.

(1) An *active* status, which is the delivery of fire on all hostile weapons as soon as their locations are confirmed.

(2) A *silent* status, which is the withholding of fire in order to provide time for the collection of counterbattery intelligence information by all available means so that a more effective program can be prepared.

(3) A *semiactive* status, which is a compromise between the active and silent status. For example, such a status may direct a silent status except for the delivery of fire on hostile locations whose fires are causing damage to friendly elements. Some artillery units may also be required to follow an active status while others follow a silent status in order to avoid disclosing the number or types of artillery units in the force.

c. Considerations Affecting the Counterbattery Tactics. Some of the considerations affecting the determination of the counterbattery tactics are—

(1) The mission of the supported force.

(2) A knowledge of the tactics and technique of employment of the enemy's artillery.

(3) The amount and types of weapons in the enemy force and the degree to which they are active.

(4) A knowledge of the enemy's capability for reinforcing his weapons.

(5) An estimation of our capability to locate enemy weapon positions.

(6) An estimate of our ability to deliver effective fire on enemy locations by appropriate means.

(7) A knowledge of the strength, status, and morale of enemy artillery units.

(8) A knowledge of the intensity or type of fire required to achieve the effect desired upon the enemy weapon locations.

(9) A knowledge of the enemy capability of locating our fire support and delivering effective fire on our positions.

(10) Employment of deception techniques to reduce the enemy's capability for locating our fire support positions.

(11) A knowledge of the communication systems employed by enemy artillery commanders and the location of enemy communication installations.

(12) Ammunition available to support the counterbattery tactics.

d. Determination of Counterbattery Tactics. The determination and application of the counterbattery tactics must guard against the creation of a standard pattern of friendly artillery fires which will reveal the plan of action to the enemy. A thorough analysis of each situation in the light of the considerations discussed in *c* above should result in the establishment of successful counterbattery tactics. When a semiactive status is selected, the artillery commander should outline his tactics in sufficient detail that subordinate artillery commanders are fully cognizant of the particulars of this status.

4. Execution of Counterbattery Fires

a. Hostile batteries should be attacked with surprise fire. Time and ammunition permitting, batteries once neutralized should be destroyed by fire. The accuracy of these fires can often be determined by sound, flash, radar, or drone.

b. Because mortars are capable of displacing rapidly and frequently, an active hostile mortar should normally be engaged as soon as it has been located with sufficient accuracy and adequate target description to insure delivery of effective counterfire.

5. Evaluation of Counterbattery Fires

During the course of operations and after enemy territory has been overrun, the effect of counterbattery fires on hostile weapon locations should be evaluated. This evaluation will facilitate future counterbattery operations by revealing the—

a. Average number of weapons in a unit.
b. Use of alternate and dummy positions.
c. Typical location and organization of weapon positions.
d. Accuracy and effectiveness of counterbattery fires.
e. Efficiency of the counterbattery intelligence system.

6. Communication

Since speed is essential to counterbattery action, the organization for operation must include an efficient means of communication for the flow of information and for calling on the most suitable weapons for fire. In most instances, the normal communication systems will suffice, but additional facilities may become necessary for the rapid transmission of information. Artillery communication channels are normally utilized for counterbattery activities. For additional information on communications see FM 6–10.

7. Terms

Certain terms, commonly used in processing target information, require explanation. The terms to be used and the criteria for their use are determined by the commander. The terrain, the enemy's employment of artillery, the weather, and characteristics of enemy weapons are considered. Examples of terms that may be required and their definitions are as follows:

a. A *roving gun location* is a location from which a roving gun is fired or from which a roving gun is suspected of being fired.

b. An *artillery (mortar) (missile) location* is an area sufficiently small in size to permit efficient attack with available weapons and which is known or suspected of containing enemy artillery weapons (mortars) (missiles).

c. A *suspect weapon location* is a location concerning which there is doubt as to whether it is occupied, unoccupied, or a dummy position.

d. A *confirmed weapon location* is an enemy position, the existence and location of which has been verified by sufficient evidence to justify the conclusion that it is occupied by an enemy weapon (s).

e. A *battery* is an enemy artillery position in which is found any of the following:

(1) Two or more light or medium artillery weapons.
(2) One or more heavy or very heavy artillery weapons.
(3) One or more artillery missiles (launchers).

8. Counterbattery Forms and Records

The following forms and records are maintained by the counterbattery officer to assist him in performing counterbattery functions.

a. The *Artillery Counterbattery Information Form* (ACIF) (DA Form 2185–R) (fig. 15) is used in recording and transmitting shelling reports (SHELREP) and information relative to hostile battery (missile) (mortar) positions. Information from this form is plotted on the hostile weapons chart, the suspect location overlay, or the SHELREP overlay. This form may be reproduced locally on 10½ by 8-inch paper.

b. The *counterbattery intelligence map* is a contour map or an aerial mosaic of suitable scale and accuracy. A contour map is preferred. This map is covered with an overlay on which are plotted appropriate unit boundaries, friendly frontlines, and all *confirmed and suspect* hostile artillery (mortar) (missile) locations.

c. The *hostile weapons chart* is a map, photomap, or grid sheet of suitable scale and accuracy on which unit boundaries, friendly frontlines, and all *confirmed* artillery (missile) (mortar) locations or batteries are plotted.

d. The *suspect location overlay* is attached to the hostile weapons chart and is used in conjunction with that chart to show suspect locations.

e. The *SHELREP overlay* is also attached to the hostile weapons chart and is used in conjunction with that chart and other attached overlays. On it are plotted the areas shelled and rays indicating the direction toward enemy weapon activity. The information on this overlay pertaining to shelled areas is particularly valuable in preparing the material for inclusion in the periodic intelligence report. The overlay may be changed as necessary, or may be changed every 24 hours, to coincide with the period covered by the periodic intelligence report.

f. The *roving gun location overlay,* when used, is attached to the hostile weapon chart and used in conjunction with that chart to show roving gun activity.

g. The *hostile (battery) file (mortar)* is a card file in which is kept a hostile weapons file card (DA Form 2186–R) (fig. 10) for each suspect artillery (mortar) (missile) location, roving gun location, and confirmed artillery (missile) (mortar) or battery location. The location designation and its complete history are recorded on this card. Confirmed locations, suspect locations, and roving gun locations are filed in separate sections.

ARTILLERY COUNTERFIRE INFORMATION FORM (FM 6-121)										
RECEIVED BY (Initials of writer)				FROM					TIME	NO.
SECTION I SHELREP - ~~MORTREP~~ - ~~BOMREP~~ (Designate which)										
A	B	C	D	E	F	G	H	I	J	K
FROM	POS OF OBSR	~~MAG OR~~ GRID AZIMUTH OF ~~SOUND,~~ FLASH ~~FURROW, OR FLT PATH ORIGIN~~	TIME FROM	TIME TO	AREA SHELLED	NUMBER, CALIBER (or size), AND TYPE OF WEAPON	NATURE OF FIRE	NO. AND TYPE SHELLS BOMBS, ETC.	TIME OF FLASH TO BANG	DAMAGE (remarks)
SECTION II LOCATION OF HOSTILE WEAPON						SECTION III COUNTERFIRE ACTION				
L	M	N	O	P	Q	FILL IN				
FROM AND TIME	GRID REFERENCE AND ACCURACY	MEANS OF LOCATING	TIME ACTIVE	NUMBER, CALIBER (or size), AND TYPE OF WEAPON	REMARKS	TIME C/FIRE	FIRED BY	NO. OF RD FUZE AND PROJECTILE		REMARKS (effect)

DA Form 2185-R, 1 NOV 58

Figure 15. Artillery Counterfire Information Form (ACIF).

9. Plotting Targets

The employment of a standard notational system facilitates the integration of information received in a variety of forms from numerous different agencies into a flexible, simple, and usable form. Although experience or the requirements of a given situation may indicate improvisation, the following described system permits the recording of the bulk of information normally received in the S2 sections:

a. Plot Description. Each location is plotted on the appropriate maps, charts, or overlays. The plot should include the concentration designation; time and date the weapon(s) was last reported active; description of the target, such as the number, caliber, and type of weapons; and the reporting source or agencies.

b. Color Code. Colors may be used in plotting to permit selection of targets according to accuracy of location. For example accuracy may be indicated as follows:

Red—accuracy of 100 meters or less
Blue—accuracy between 101 and 200 meters
Brown—accuracy between 201 and 300 meters
Green—accuracy of 301 meters or over

c. Identification of Reporting Source or Agency. The abbreviations most commonly used to identify the reporting source or agency are—

SR—Sound ranging
RR—Radar
FR—Flash ranging
Z—Shelling reports ((g) for crater analysis; (f) for flash observation)
TAF—Tactical Air Force observer
POW—Prisoner of war
AOP—Air observer
OP—Ground observer
II—Image interpreter

d. Plot Designation. Reported target locations are designated by a concentration designation. Plots are placed on the suspect location overlay until confirmed. When a location is confirmed, the plot is removed from the suspect location overlay, plotted on the hostile weapons chart, and the letter C (confirmed) is added to the concentration designation. The corresponding card in the hostile artillery file is changed accordingly.

e. Description of Target. An abbreviated description of the target's composition is included as a part of the plot.

(1) The description of hostile artillery locations includes the number, caliber (or size), and type of weapon(s), for example—

4/M/H	Four medium howitzers
1/?/?	One weapon; caliber (or size) and type doubtful.

3/H/? Three heavy weapons, type doubtful
4/150/G Four 150-mm guns (show exact size or caliber when known).
1/MR/MSL One medium-range missile (show exact size when known).

(2) Mortar locations are described as to the number and size of mortars therein: for example—
4/Lt Four light mortars
1/? One mortar, size doubtful
1/Hv One heavy mortar

(3) The criteria for classifying enemy artillery and mortars should be established by the corps artillery commander, using order-of-battle intelligence and appropriate information of the enemy as a guide. The larger enemy mortars may be classified as artillery.

(4) General target locations are described by an appropriate military symbol (FM 21–30) or abbreviation or by improvising some other intelligible notation.

f. Completed Plot. The completed plot (fig. 16) consists of the basic symbol, with notations placed in each quadrant. A commonly used system for entering notations is given below:

(1) Upper left—concentration number assigned to the location.

(2) Upper right—date and time last active or reported. (If derived from photointerpretation report, the data and time the photo was taken are shown.)

(3) Lower right—agency reporting. More than one may be shown.

(4) Lower left—description of target.

g. Changes in Target Status. The plots of targets are changed to conform to the target's known status. For example, the plot may be removed from the suspect location overlay and replotted on the hostile battery chart when the location is confirmed (*d* above). When a target location is reported by a reliable source to be vacated, its plot is removed from the general target overlay or the hostile weapons chart and, in the case of artillery (mortars), the plot is reentered on the suspect location overlay. Regardless of the type of target, the card of the location now reported to be vacant is retained in the suspect section of the appropriate target file for reference if the location is reoccupied and to facilitate post-strike analysis.

10. Shelling Reports

a. Whenever and wherever hostile shelling (cannon, missile, or mortar) or hostile bombing is observed, it must be reported with-

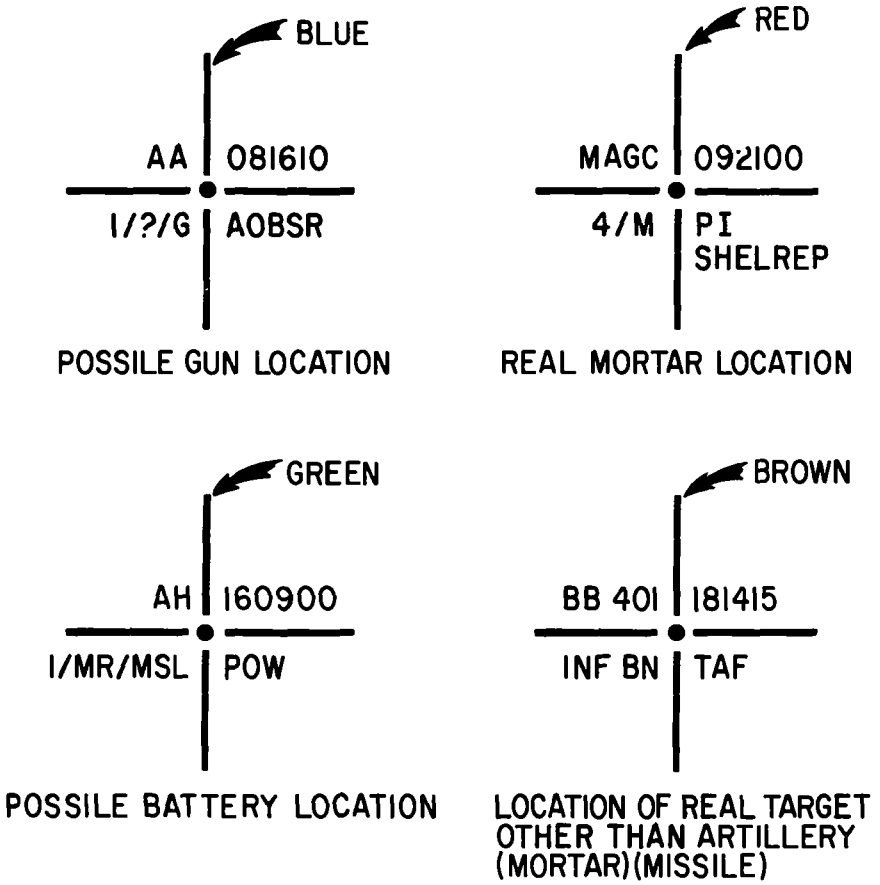


Figure 16. Target plot.

out delay to the headquarters best equipped to evaluate and act upon the information. This report is forwarded in accordance with the format and procedure prescribed in paragraph 13.

b. Shelling and bombing reports form the basis of efficient counteraction to enemy fire. In addition to providing information that facilitates the initial location of hostile weapons, shelling and bombing reports further aid counterbattery, countermortar, and air defense operations by—

(1) Indicating *when* enemy weapons are firing.
(2) Indicating *which* weapons or planes are active.
(3) Indicating the *number*, *caliber* (*or size*), and *type* of active weapons.

(4) Reporting the *effectiveness* and indicating the *purpose* of enemy fire.
(5) Helping to define enemy fire *capabilities*.
(6) Furnishing information which may confirm target locations.

11. Plotting Shelling Reports

a. Shelling reports are plotted on the SHELREP overlay (fig. 17) as they are received.

(1) The basic symbol used in plotting a shelling report is a ray whose origin is at the observer's reported location. However, if the shelling report is based on measurements taken at the crater or furrow, the area shelled ((3) below) is the origin of the ray. For "flash-bang" reports (par. 9*i*, app. III), the rays are drawn with tick marks which correspond to the ranges determined from reported time intervals.

(2) To permit rejection of false intersections, the rays may be drawn according to a color code. For example—
Red—heavy weapons (caliber or size)
Blue—medium weapons (caliber or size)
Green—light weapons (caliber or size)
Brown—missiles (size or short-, medium-, or long-range)
Black—unknown

(3) When the location of the area shelled is reported, it may also be shown on the shelling report overlay. Notations concerning the number and caliber (or size) of the shells fired, the nature of the fire, and the time fired are desirable.

(4) Notations are placed on the ray to identify the SHELREP. These notations normally include the time of firing; the ACIF number; information concerning the number, caliber (or size), and type of weapons; and the flash-bang distance if reported in item J, ACIF.

b. SHELREPS are evaluated on receipt as to accuracy and reliability. When the SHELREP is plotted on the SHELREP overlay it is considered in conjunction with the hostile weapons chart, attached overlays, and any other pertinent information available. If the SHELREP establishes the activity of a hostile location an entry is made on the appropriate target file card and hostile weapons chart. When appropriate, the information is passed to the S3 for information and necessary action. When the azimuth or location is unrelated to any plotted location, a careful study is made taking into account weapon type and caliber (or size) to determine likely

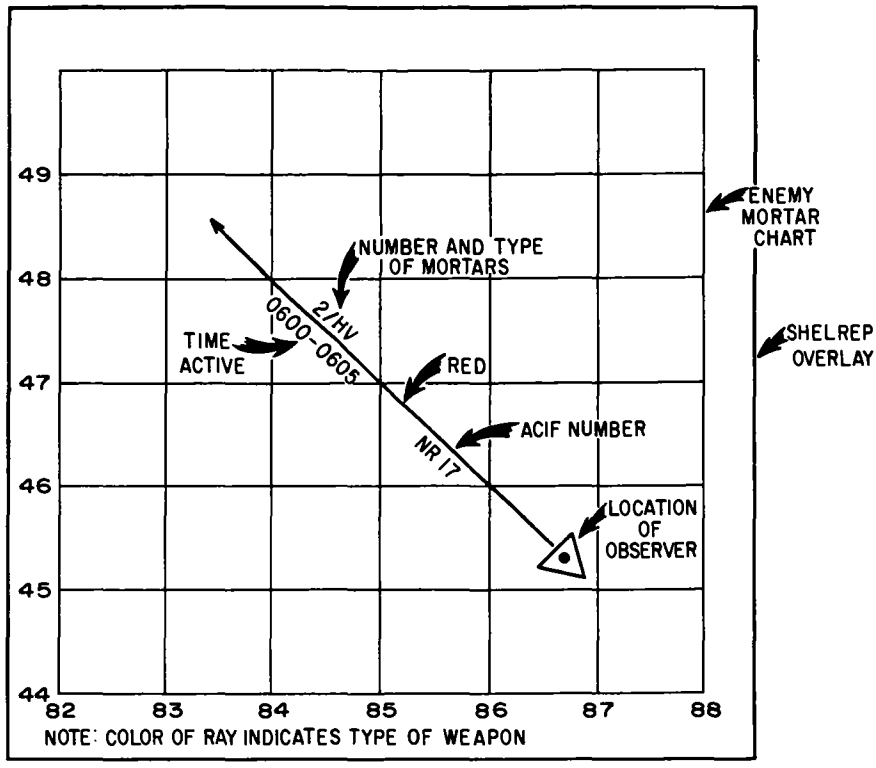


Figure 17. SHELREP plot.

tactical positions. Intelligence agencies may be directed to see further information in these areas.

12. Reporting Types of Shells

a. Shells or fragments not positively identified should be reported immediately to the S2. For technique of fragment analysis, see TM 30–240.

b. To be of maximum value, fragments should be tagged with the following information:

(1) Date and time the shell landed, if known.

(2) Location of point where the shell was found, as accurately as possible.

(3) Direction from which the shell came and method used in determining that direction (survey of crater, sound, etc.).

(4) Name and organization of person making the report.

(5) Reference to shelling report on which this shell was reported, if known.

13. Specific Values of Reports

a. Shelling (SHELREP) Reports. Shelling reports furnish valuable information concerning the disposition and activities of the hostile weapons. By a detailed analysis of shelling reports, the artillery intelligence officer obtains information that may permit the location of hostile weapons and effective employment of counterbattery fires.

b. Bombing Report (BOMREP). Bombing reports provide valuable information to the intelligence sections of higher headquarters, both air and ground. They are used in the preparation of enemy air order-of-battle studies. If properly processed and analyzed, they indicate enemy air capabilities and intent as well as new developments, tactics, and doctrine.

14. Detail and Accuracy

The most reliable, accurate, and informative reports of hostile shelling or bombing are based on visual or electronic observation supplemented by crater and fragment identification. Reports (SHELREP, BOMREP) should be as detailed and accurate as the necessity for speed will permit. *No individual should neglect or delay a report due to lack of complete information.* Fragmentary or incomplete information is often of value in supplementing or confirming existing information. All personnel, regardless of the arm of service, must be made aware of the necessity for reporting promptly shelling or bombing information that comes to their attention. However, the greatest volume of usable reports is submitted by specially trained personnel. Provision should be made for the training of such specialists within units of company-size and larger.

APPENDIX III

CRATER ANALYSIS AND SHELREPS

Section 1. LOCATION OF HOSTILE GUNS AND HOWITZERS BY CRATER ANALYSIS

1. Gun and Howitzer Shell Crater Analysis

a. The projectile's direction of flight can be determined with reasonable accuracy from its crater or ricochet furrow. By accurately locating the crater and measuring the direction of flight, it is possible to obtain the azimuth of a ray that will pass through or near the enemy position. An enemy battery may be located by plotting the intersection of the average back-azimuths from two or more widely separated groups of craters from shells known to have been fired by that battery. It is also possible to determine the direction to a battery with fair accuracy from the back-azimuth obtained from one crater or ricochet furrow.

b. In crater analysis, differences in slopes of fall, projectile burst patterns, directions of flight, and time fuze settings will help to distinguish between enemy batteries firing on a given area.

2. Value of Analysis

By analyzing shell craters, it is possible to—

a. Verify, as confirmed locations, suspected locations that have been obtained by other means.

b. Detect the presence and approximate location of enemy batteries.

c. Obtain an early indication of the general location or direction of active enemy artillery.

d. Assist the counterbattery intelligence missions.

e. Detect the presence of new types of enemy weapons, new calibers, or new ammunition manufacturing methods.

3. Inspection of Shelled Areas

Inspections of shelled areas are made as soon as possible after the shelling. Reverse slopes, folds in the terrain, hedgerows, and buildings in shelled areas often show ricochet furrows and other markings.

4. Survey of Crater Location

Areas must be accurately located for plotting on charts, maps, or aerial photographs. Deliberate survey is not essential; inspection, or inspection and short traverse using the aiming circle or a compass for direction and pacing for distance, will do.

5. Determination of Direction

a. Pattern. A clear pattern produced on the ground by the detonating shell indicates the direction from which the shell came.

b. Factors Affecting Pattern.

(1) It must be remembered that due to terrain irregularities and soil conditions, typical shell crater patterns are the exception, not the rule. Side spray marks compose the principal parts of the pattern caused by fragmentation. There is much less effect from nose spray. Base spray is negligible from gun and howitzer projectiles but appreciable from mortars. The width, angle, and density of the side spray pattern vary with the projectile, the angle of impact, and the terminal velocity of the projectile.

(2) In determining direction, the effect of stones, vegetation, stumps, roots in the path of the projectile; variations in density and type of soil; and the slope of the terrain at the point of impact are considered. From any group, only the most clearly defined and typical craters are used.

c. Marks on Vegetation and Other Subjects. The direction from which a round was fired is often indicated by the marks made as it passes through trees, snow, and walls. The possible deflection of the shell upon impact with these objects must be considered, and evidence of such deflection should not be overlooked.

d. Drift and Wind Effects. Drift and lateral wind effects do not materially change the direction of the shell's axis during flight. The ricochet furrow, or path, will usually be parallel to the plane of fire except when obviously deflected.

e. Ricochet Furrows.

(1) Ricochet furrows usually furnish the most accurate information regarding the projectiles direction of flight. The average direction of a few good furrows *from the same battery* will give a line that passes close to the battery position. Care must be taken, however, to determine that the shell was not deflected before or while making the furrow. *Shells often change direction at the point where a ricochet changes from a descending to an ascending path.*

(2) Loose dirt should be carefully removed from the furrow by hand, leaving the smooth, hard channel intact. A stake or survey pin should be driven into the ground *at each end of the usable straight part of the furrow.* The stakes must be driven straight and just touching the centerline of the channel on the same side. The line between these stakes represents the line of fire. The azimuth of this line can be measured with an aiming circle (fig. 18).

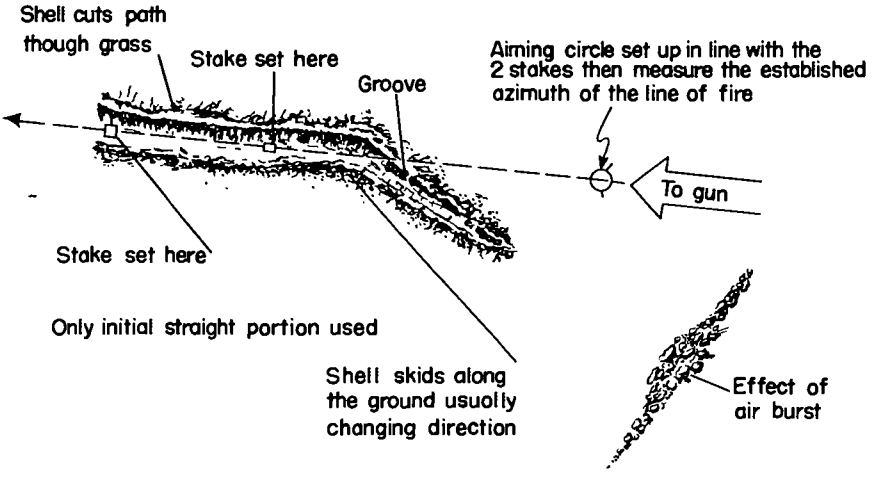


Figure 18. Typical ricochet markings (vertical view).

f. Fuze-Quick Craters.

(1) At small angles of fall, fuze-quick craters furnish information nearly as accurate as that from ricochet. Determining the direction of the trajectory becomes more difficult with an increase in the angle of impact, as a result the analysis of more than one crater is required. When the angle of impact is small or moderate, the crater is generally pear-shaped. When the angle of impact is larger, the crater is generally oval with the smallest diameter in the direction of flight.

(2) The direction of flight can be determined by examining the—

(*a*) Groove in the ground where the shell enters (fig. 19). To determine the direction, place a stake in the center of the channel. Place a second stake on the opposite side of the crater. Sight along these stakes to obtain the back-azimuth. Fuze tunnels or grooves usually indicate the direction of fire.

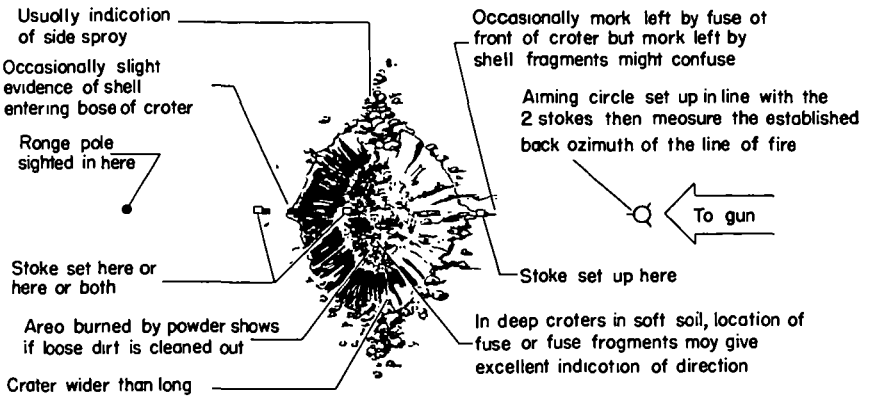


Figure 19. Schematic shell crater, fuze-quick (vertical view).

(*b*) Side spray effects (hatchet stroke) as shown by dirt and cut grass. Place a stake near the end of each side spray (hatchet stroke) to divide the spray marks in half (fig. 20). Place the aiming circle over the center of the crater and measure the angle between the stakes. The bisector of this angle is the approximate line of fire. Determine its back-azimuth.

(*c*) The mean of the back-azimuths obtained from the

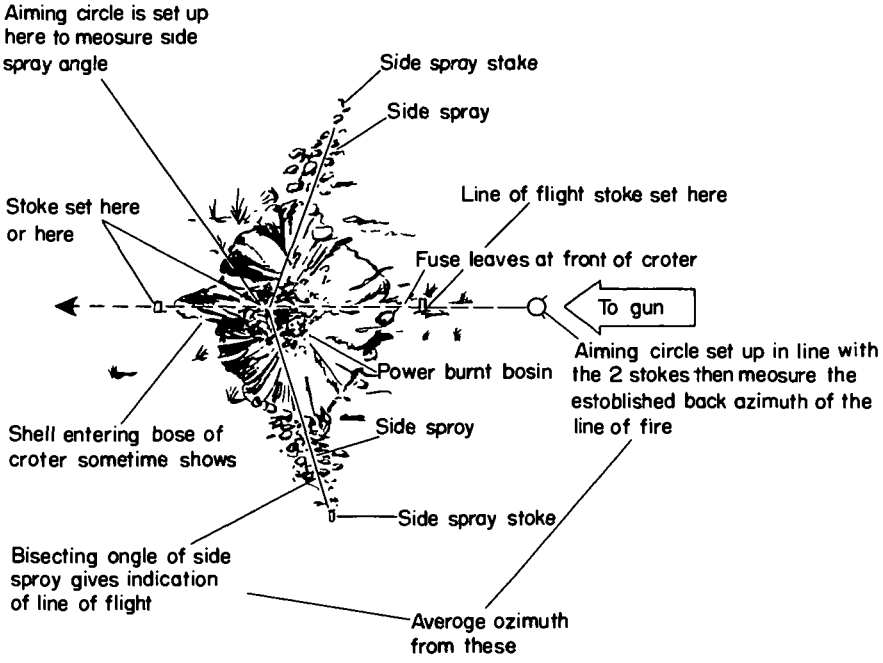


Figure 20. Determination of direction by side spray (vertical view).

operations described in (*a*) and (*b*) above is more dependable than the back-azimuth obtained from either method alone.

g. Deep Craters. The analysis of deep craters are the least reliable in determining direction of flight. In soft soil, good direction can be obtained if a nose fuze has been used. A nose fuze will form a tunnel prolonging the shell's line of flight, and the line of fire can be determined from this tunnel and other characteristics. Crater patterns are usually oval with the smallest diameter indicating the direction of fire.

Section 2. LOCATION OF HOSTILE MORTARS BY CRATER ANALYSIS

6. Mortar Shell Crater Analysis

Mortar shell crater analysis is similar to the analysis of gun and howitzer craters. In fact, it is sometimes difficult to differentiate between craters of light howitzer and mortar projectiles.

7. Appearance of Craters

Mortar craters are characterized by the following:

a. At the front edge (one farthest from the mortar position) of the crater, the turf is undercut (fig. 21) while the back edge is shorn of growth and grooved or streaked by splinters.

b. When fresh, the crater is covered with loose earth which must be removed carefully to disclose the firm, burnt, inner crater (fig. 21).

c. The fuze is buried in the bottom of the inner crater in front of the point of detonation (fig. 21). In soft ground, the fuze will be buried deeply along the line of the trajectory.

d. The ground around the crater is streaked by splinter grooves, radiating from the detonation point (fig. 21). The groove pattern depends on the angle of fall and the type of soil. Frequently the ends of the splinter grooves on the rear side of the crater will be on a straight line. This line is perpendicular to the line of flight on level ground or on slopes with contours perpendicular to the plane of fire (fig. 21).

8. Determining Direction to Mortars

a. Three methods may be used to determine the line of flight from a mortar crater. They are as follows:

(1) Drive a stake in the crater with the top at the intersection point of splinter grooves ((1), fig. 22). Carefully remove loose dirt. Look for fins and fuze fragments. Do not disturb the firm sides of the fuze tunnel; the tunnel is

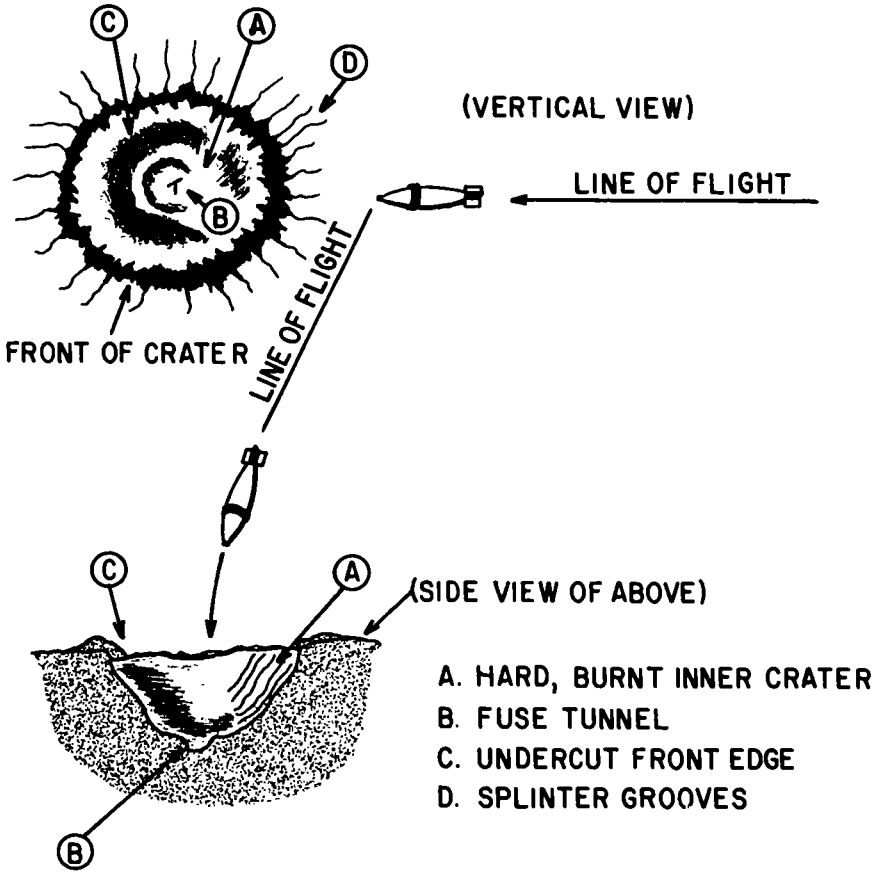


Figure 21. Schematic mortar crater (vertical and side views).

useful in determining direction. Lay a stick along the line from the fuze or tunnel to the stake. Measure the azimuth of the stick. This is the approximate azimuth to the mortar.

(2) Lay one stick along the ends of the splinter grooves on the side of the crater toward the enemy mortar and place another stick at right angles to the first ((2), fig. 22). Measure the azimuth of the second stick.

(3) When a definite and regular crater is formed, a stick can be laid across the crater along its main axis, dividing the crater into halves. The stick points in the direction of the mortar ((2), fig. 22).

b. The value of each method described in (1), (2), and (3) depends on soil type and ground form. Usually, direction is best determined by a combination of the three methods.

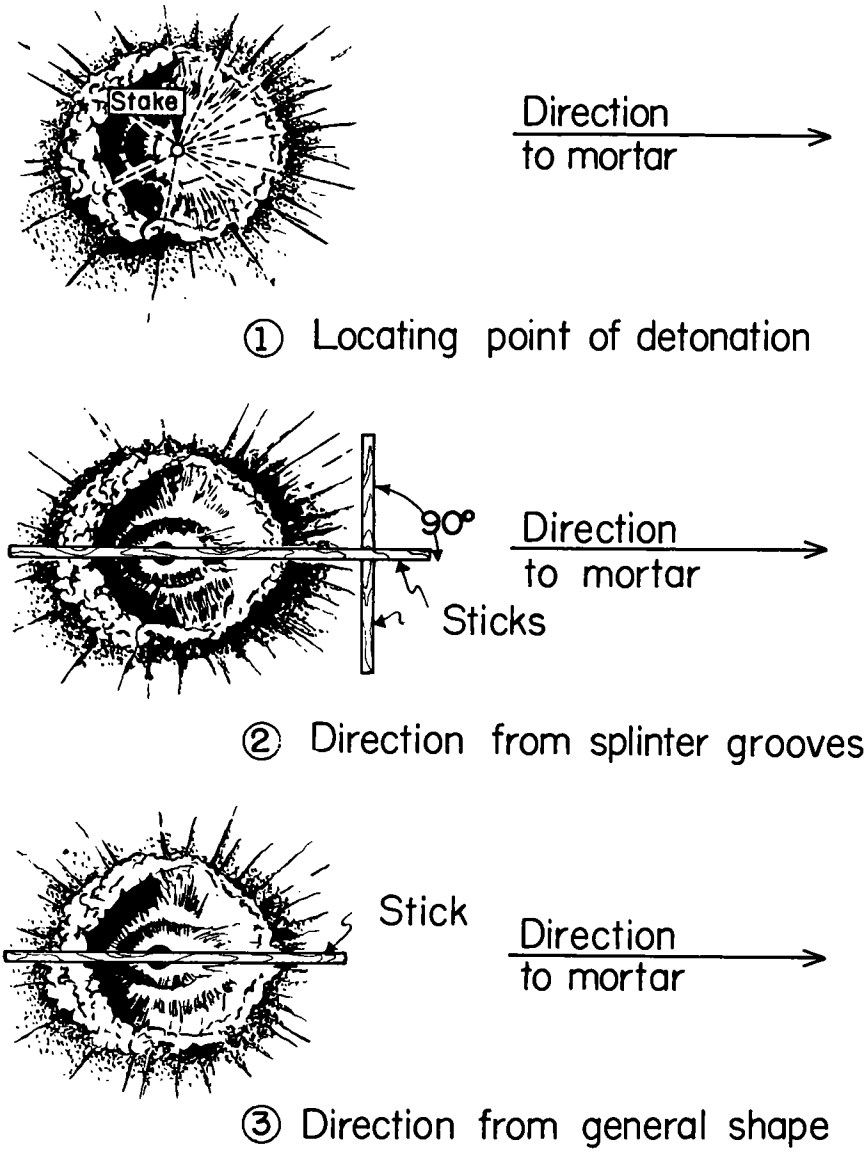


Figure 22. Determination of the line of flight from a mortar crater (vertical view).

c. Determination of the angle of fall (fig. 23) is valuable in computing the range to the enemy weapon. When the fuze hole is deep and well-defined, a long, straight stick should be placed in the center of the fuze tunnel to reconstruct the terminal portion of the trajectory. With the stick properly placed, a protractor and plumb bob can be used to measure the angle of fall. For most

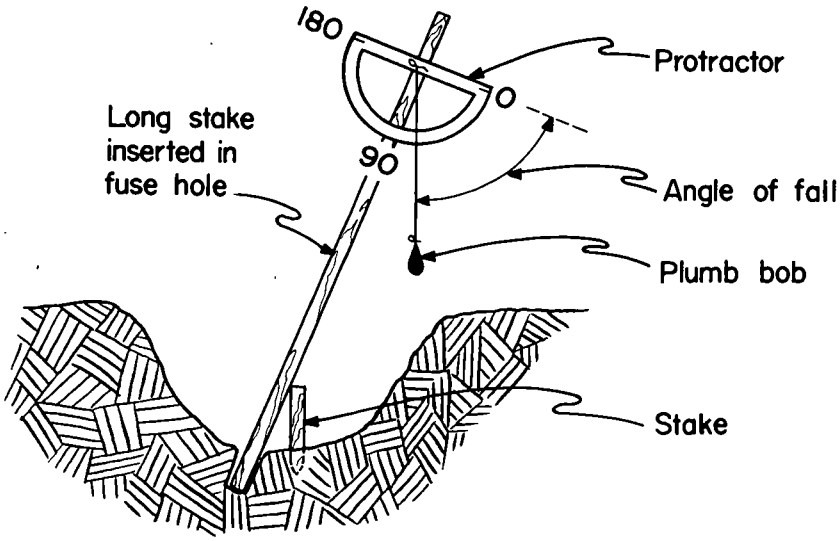


Figure 23. Determining angle of fall from a mortar crater (side view).

accurate results, the mean angle of fall from a number of craters made by the same weapon should be used.

d. When only one azimuth to the mortar position can be determined, the range to the position may be found from the angle of fall (*c* above). The type and caliber of weapon are determined from identification of shell fragments and tail fins. To use this system, counterfire personnel must have the firing table of the enemy weapon.

Section 3. SHELLING, MISSILE, OR BOMBING REPORTS

9. Content

Items to be included in SHELREP's missile reports (MSLREP) and BOMREPs are transmitted in the following order:

a. Item A, From. This identifies source of the report. A current call sign or code name is used.

b. Item B, Position of Observer. A map reference is preferred. It must be encoded using a grid reference code, map template, thrust line, or other security means. Item B may at times reflect only the letter F. This indicates that the observer's location is the same as the coordinates contained under item F. Likewise, item F may contain only the letter B, indicating that the area shelled was the same as the location of the observer.

c. Item C, Grid or Magnetic Bearing Azimuth of Flash, Sound, Origin of Flight Path, or Groove of Shell in Mils or Degrees. The

observer must state whether he is reporting a grid or magnetic azimuth, how the direction was determined (whether from flash, sound, observation of the flight path, or sighting along the shell's furrow), and the unit of measure used (mils or degrees). Azimuth is measured from the observer to the enemy weapon. This item is omitted from bombing reports. The azimuth to the suspected enemy area can be determined—

(1) *By sound.* Estimation of azimuth by ear is the most common but the most inaccurate method used. It should be confirmed by other methods.. Hearing gunfire and measuring the azimuth to the area from which the sound came or hearing the passage of the shell and measuring the azimuth of its course are the two methods most often used.

(2) *By flash.* Estimation of azimuth by flash is more accurate. However, since flash simulators may be used, locations must, if possible, be confirmed by other methods.

(3) *By observation of the flight path.* The location of a missile launcher can often be determined by observing the flight path to burnout, and then measuring the azimuth to its origin.

(4) *By crater and furrow analysis (par. 5–8).*

d. Items D and E, Time from (D) and Time to (E). The times from the beginning to the end of the shelling or bombing should be given accurately. It is possible that the location can be confirmed by sound or flash locations which were taken at the same time or that the reports of two or more observers can be combined. Consequently, reports should not be delayed until the shelling or bombing ceases. Fragmentary reports are submitted immediately, followed by complete reports when they are obtained.

e. Item F, Area Shelled or Bombed. The area shelled or bombed is preferably identified in the clear by map reference. The precision with which targets are attacked by the enemy may indicate the enemy's use of forward observers (FO's), photographs, map data, or sound, flash and radar units. The intensity of the persistency of shelling or bombing may indicate the value of the target to the enemy, the status of his ammunition supply, and whether the fire is defensive or offensive.

f. Item G, Number, Size, and Type of Cannon, Missiles, or Aircraft. The number of cannon is estimated from the time that elapses between individual bursts or from the number of bursts that occur within a few seconds. The caliber of shell and the time needed to reload is also considered. The caliber and the type of shell are determined by identification of fragments. (Initially, the caliber may be estimated.) Difficulty in determining the number,

size, and type of missiles will vary with the missile and the type of warhead. The slow rate of fire and other characteristics of the larger missiles should make their identification relatively simple.

g. Item H, Nature of Fire (Omitted for BOMREP). Nature of fire may be classed as registration, destruction, interdiction, harassing, or neutralization or fire against a specific installation. The nature of the fire often indicates the necessity of speed in counterbattery fire.

h. Item I, Number and Type of Shells, Missiles, Bomb, Etc. This item includes information about the kind of shell (nuclear, high explosive, time, incendiary, gas, etc.) or bomb (nuclear, fragmentation, cluster, incendiary, napalm, etc.) used.

i. Item J, Time of Flash to Bang (Omitted in BOMREP). One means of establishing the distance from the observer to the gun is by noting the number of seconds between the gun flash and the sound of the discharge of the gun. For practical purposes in computing the approximate distance between the gun and the observer, it is assumed that flashes are seen instantaneously and that the speed of sound is approximately 340 meters per second. The calculation of this distance, which is based on the speed of sound, is not related to the time of flight.

j. Item K, Damage. This item states the damage inflicted and provides information which might indicate needed changes in procedures or actions. Whether item K is transmitted in clear or encoded text will depend on the situation. Occasionally, it may be desirable to report damage separately by flash message.

10. Transmission

a. Since speed is essential in counteraction, observers transmit SHELREP's, MSLREP's, and BOMREP's by the most rapid means available.

b. Each report will be preceded by the appropriate code word.

(1) SHELREP (in case of enemy gun, howitzer or mortar fire).

(2) MSLREP (in case of missile fire).

(3) BOMREP (in case of enemy air bombardment).

c. For ease and speed in transmission, each item of the report will be identified by a capital letter; e.g., A, B, C. Item titles (number and type of shells, missiles, mortars, bombs, etc.) will not be transmitted.

d. Messages will always be transmitted in the clear except for—

(1) Item A (par. 9), Unit. Current call signs or code names are used instead.

(2) Item B (par. 9), Location of the observer. When map references are used, they must be encoded.

(3) Item K (par. 9), Damage. For discussion, see paragraph 9*j*.

11. Artillery Counterfire Information Form

When a SHELREP is combined with information locating enemy weapons and a record of counterbattery, artillery counterfire information form (DA Form 2185–R) (figs. 24 and 25) may be used. On this form, section I is the SHELREP (par. 9), section II is pertinent to hostile battery location, and section III provides data for S3 action.

a. Section II. Location of Enemy Weapon. The following items are included in section II of the artillery counterfire information form:

(1) *Item L, from and time*—Identification of the sending agency and message time.

(2) *Item M, grid reference and accuracy*—Grid reference of the enemy weapon and estimated accuracy of location.

(3) *Item N, means of locating*—Source of information; e.g., flash, radar, air, or OP.

(4) *Item O, time active*—Time the enemy weapon was active, including the date, if not current.

(5) *Item P, number, caliber, and type of weapon*—The number of weapons located and their caliber and type (guns, howitzers, mortars, or missile).

(6) *Item Q, remarks*—Any additional pertinent information; e.g., construction of emplacements, location of truck park, personnel activity, or the effects of fire. Radar reports will include the coordinates of the impact area.

b. Section III, Counterbattery Action. Section III is completed by the S3 after counterbattery has been directed against the enemy weapon. It includes time of counterbattery, unit firing, number of rounds fired, fuze, projectile, and the effect.

ARTILLERY COUNTERFIRE INFORMATION FORM
(FM 6-121)

RECEIVED BY (Initials of writer)	FROM	TIME	NO.
A.U.S.	LA 01	1300	7

SECTION I SHELREP - ~~MORTREP~~ - ~~BOMBREP~~ (Designate which)

A	B	C	D	E	F	G	H	I	J	K
FROM	POS OF OBSR	~~MAG OR~~ GRID AZIMUTH OF ~~SOUND,~~ FLASH ~~FURROW, OR FLT PATH ORIGIN~~	TIME FROM	TIME TO	AREA SHELLED	NUMBER, CALIBER (or size), AND TYPE OF WEAPON	NATURE OF FIRE	NO. AND TYPE SHELLS BOMBS, ETC.	TIME OF FLASH TO BANG	DAMAGE (remarks)
OP #1	365487	1438 ~~MM~~	1250	1255	?	2/?/?	?	18/?	8 secs	?

SECTION II LOCATION OF HOSTILE WEAPON

SECTION III COUNTERFIRE ACTION

L	M	N	O	P	Q	FILL IN			
FROM AND TIME	GRID REFERENCE AND ACCURACY	MEANS OF LOCATING	TIME ACTIVE	NUMBER, CALIBER (or size), AND TYPE OF WEAPON	REMARKS	TIME C/FIRE	FIRED BY	NO. OF RD FUZE AND PROJECTILE	REMARKS (effect)

DA Form 2185-R, 1 NOV 58

Figure 24. Artillery counterfire information form showing SHELREP recorded.

ARTILLERY COUNTERFIRE INFORMATION FORM
(FM 6-121)

RECEIVED BY (Initials of writer)	FROM	TIME	NO.
R. J. W.	S2, 1ST Bn, 16TH Arty	1258	1

SECTION I SHELREP - MORTREP - BOMREP (Designate which)

A	B	C	D	E	F	G	H	I	J	K
FROM	POS OF OBSR	MAG OR GRID AZIMUTH OF SOUND, FLASH FURROW, OR FLT PATH ORIGIN	TIME FROM	TIME TO	AREA SHELLED	NUMBER, CALIBER (or size), AND TYPE OF WEAPON	NATURE OF FIRE	NO. AND TYPE SHELLS BOMBS, ETC.	TIME OF FLASH TO BANG	DAMAGE (remarks)

SECTION II LOCATION OF HOSTILE WEAPON						SECTION III COUNTERFIRE ACTION			
L	M	N	O	P	Q	FILL IN			
FROM AND TIME	GRID REFERENCE AND ACCURACY	MEANS OF LOCATING	TIME ACTIVE	NUMBER, CALIBER (or size), AND TYPE OF WEAPON	REMARKS	TIME C/FIRE	FIRED BY	NO. OF RD FUZE AND PROJECTILE	REMARKS (effect)
1ST FA Bn 16TH Arty Radar 1257	478675 100 meters	Radar	1255	1/?/?	Area Shelled 490650	1300	1ST FA Bn 16TH Arty	36 Fz 50% FQ 50% VT	under surveillance op #1

DA Form 2185-R, 1 NOV 58

Figure 25. Artillery counterfire information form showing location of a hostile weapon and action taken.

APPENDIX IV

AERIAL PHOTOGRAPHY

Section 1. GENERAL

1. Determining the Scale of Vertical Photographs

a. Procedures for determining the scale of vertical photographs are presented in FM 21–26, TM 30–245 and TM 11–401.

b. The marginal data tabulated on photographs are described in TM 30–245 and TM 11–401.

2. Converting Photographic and True Measurements

a. Setting Relationship on Military Slide Rule. Photographic measurements may be converted to true distance (and true distance to photographic distance) by use of a military slide rule or graphical site table. This is done by setting the photo distance (a number of units obtained with any convenient plotting scale) on the C scale of the slide rule directly over the true ground distance (meters) on the D scale. Once this setting has been obtained, any photographic measurement with the same plotting scale from the photograph can then be converted to true ground distance by moving the hairline to the photographic measurement on the C scale and reading the true ground distance under the hairline on the D scale.

Example. The true ground distance between two points identified on a photograph has been determined to be 1,500 meters. By using a plotting scale, the distance between the two points on the photograph is measured as 1,800 units. This photo distance (1,800) on the C scale is set over the true ground distance (1,500) on the D scale. To convert a photographic measurement (e.g., 2,100 units to true ground distance) the hairline of the indicator is placed over 2,100 on the C scale and the true ground distance (1,750) is read from the D scale (fig. 26).

b. Computing Relationship. Photographic measurements may be converted to true distance (and true distance to photographic distance) by the use of the photo-ground relation. If the true (ground) distance between two points (A and B) which appear on a photograph is known, the distance measured (using any con-

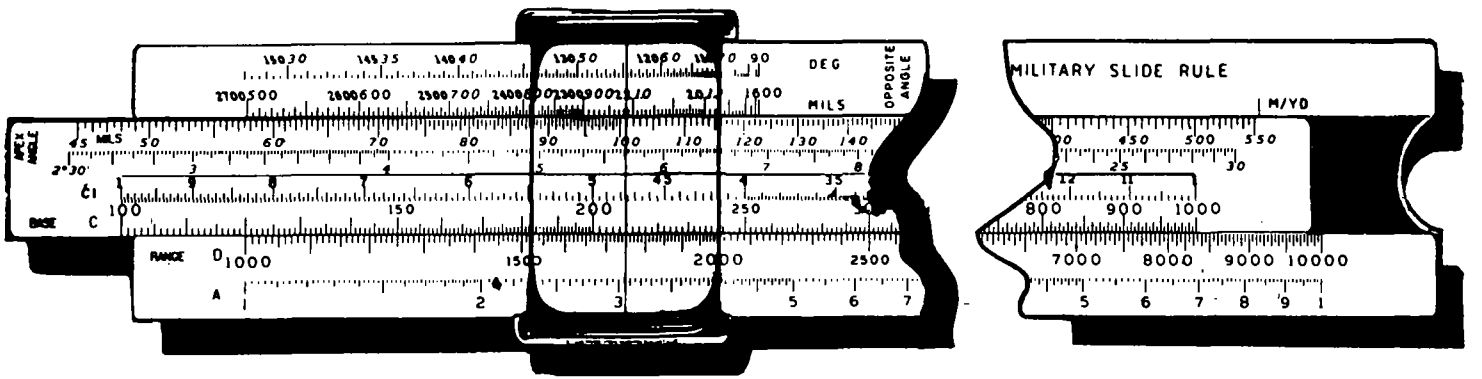


Figure 26. Method of using military slide rule for conversion of photographic measurements to true ground distance.

venient units) on the photograph from A to B divided by the ground distance from A to B is the photo-ground relation and is expressed by the ratio

$$\frac{\text{AB photo (units)}}{\text{AB ground (meters)}}$$

The relation of the distance between any other two points on the photograph, (for example C and D) to the ground distance between the same two points is expressed by the same ratio, i.e.,

$$\frac{\text{AB photo (units)}}{\text{AB ground (meters)}} = \frac{\text{CD photo (units)}}{\text{CD ground (meters)}}$$

Therefore, if the photo distance from C to D is measured, the ground distance from C to D can be computed by transposing the previous equation to the following:

$$\text{CD ground (meters)} = \frac{\text{AB ground (meters)}}{\text{AB photo (units)}} \times \text{CD photo (units)}$$

For example, the measured distance between two points on the ground is 1,500 meters, and the scaled distance between the same two points on the photograph is 1,800 units. To convert a photographic measurement of 2,100 units to true ground distance, the following equation is used:

$$\frac{X}{2100} = \frac{1500}{1800};\ X = \frac{2100 \times 1500}{1800} = 1{,}750 \text{ meters true ground distance}$$

Section 2. DISTORTION IN AERIAL PHOTOGRAPHS

3. Distortion in Aerial Photographs

An aerial photograph of absolutely level ground taken by a camera with its axis truly vertical would result in a picture in which the relative location of points on the picture would be the same as on the ground or a map (fig. 27). However, the vertical photograph is subject to distortion of detail caused mainly by the tilt of the camera and the relief of the terrain photographed.

4. Tilt

If the camera is not level at the instant the photograph is taken, the scale of the photograph will not be uniform. In figure 28, it is evident that a horizontal line of a certain length appearing on a photograph near X will appear longer than a line of the same length appearing on the same photograph near Y, since X is nearer the camera than Y. When the amount of tilt in a photograph is small, the resulting errors are negligible for artillery purpose. In a series of overlapping photographs taken on a single flight, excessive tilt of the camera in taking one of the photographs is

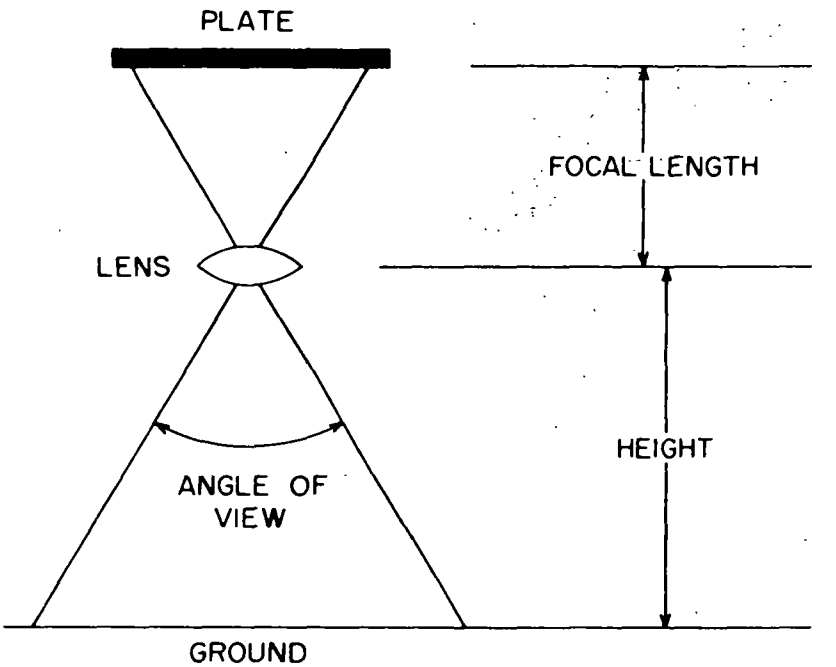


Figure 27. Photographic-ground relationship of a true vertical photograph.

apparent if the center of that photograph deviates materially from the line of centers established by other photographs. If the amount of tilt is great enough to distort a vertical photograph, that photograph cannot be used for restitution of points onto a firing chart. Photographs taken with excessive tilt normally are not sent to using units; if an artillery unit does receive such photographs, the unit should request corrected prints with the effects of tilt removed. Artillery units are not equipped to remove the effect of tilt from photographs. Tilt is discussed in more detail in TM 5–230.

5. Relief

a. General. The other important source of error in vertical photographs is relief. A point at a higher altitude than the datum plane appears farther from the photo center than it should. Considering figure 29 as any vertical section through the axis of the lens, Z will be recorded in its true position, the center of the photograph, regardless of its altitude. With reference to a horizontal datum plane (MN), an object (X) at a greater altitude will appear to be farther from the photo center than it actually is (X′) ; an object at a lower altitude will appear closer (Y will record as Y′). These displacements are radial from or toward the plumb point (point directly beneath the camera lens at the instant the

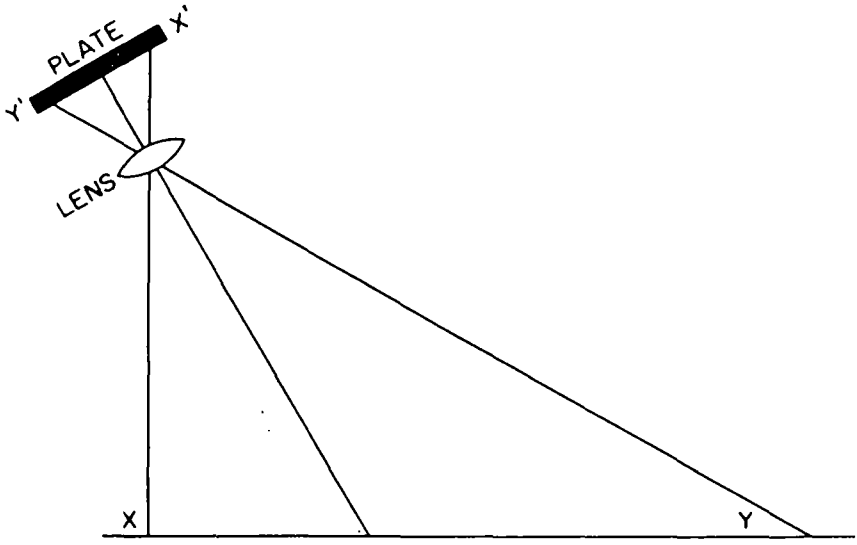


Figure 28. Effect of tilt.

photograph is taken—also referred to as nadir, ground). If the amount of tilt is small, the plumb point and the center of the photograph can be considered to be the same. With the aircraft at a given altitude above the horizontal datum plane, the amount of displacement varies directly with the horizontal distance from the photo center (Z) and the vertical interval between the object and the horizontal datum plane. Directions of the radial lines, ZX and ZY, are not changed by the displacement of X and Y. The relief distortion of any particular point varies inversely as the altitude of the airplane varies.

b. Effect of Relief Displacement on Direction and Scale. The effect of relief is the displacement of images radially from or toward the center of the photograph. In figure 30, the points X and Y are on ground higher than the center of the photograph and point Z is on ground lower than the center of the photograph. In the figure, X, Y, and Z represent the true locations of these points, whereas X′, Y′, and Z′ represent the photographic locations. The lines X′Z′ and X′Y′ are not true direction lines, whereas PX′, PY′, and PZ′ are true and Y′Z′ is approximately true. Therefore, the directions of lines passing through or near the center of an average vertical photograph are substantially true. However, lines passing well away from the center and joining points of different altitudes whose images lie in the outer field of the photograph may show excessive errors in direction when relief is considerable. If the altitude from which the photograph was taken is known, the

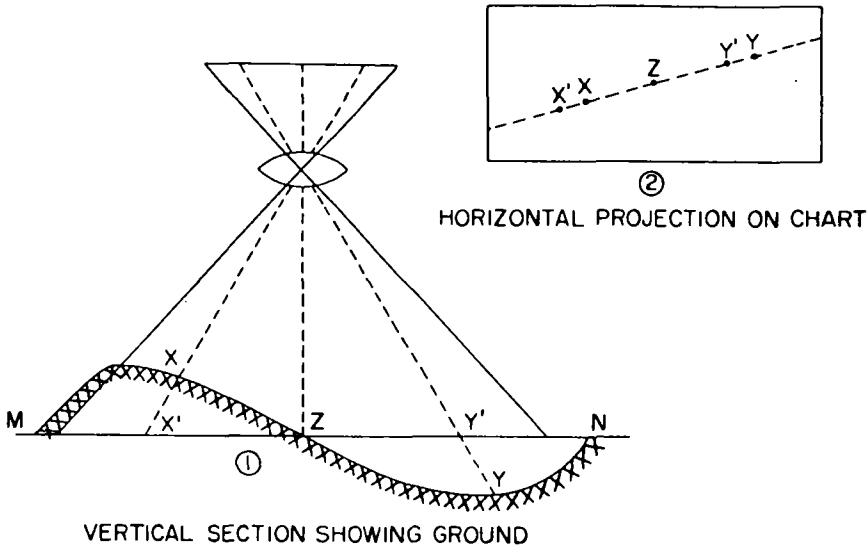


Figure 29. Displacement due to relief of ground.

error may be corrected by a replot of the points to place them on the same datum plane.

c. Determination of Relief Correction (fig. 31). The amount of distortion due to relief can be found by solving the following equation:

$$\frac{d}{D} = \frac{h}{H}$$

d is the displacement correction in meters (photo dis-

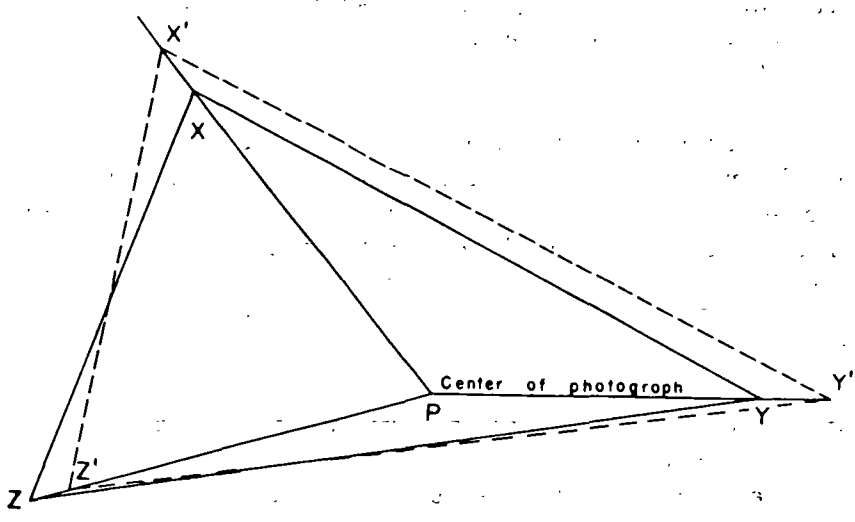


Figure 30. Effect of relief displacement on direction and scale.

tance) radially toward (from) the center of the photograph.

h is the height of ground above (below) the horizontal datum plane.

D is the distance in meters (photo distance) from the center of the photograph to the point to be corrected. (D may be measured with 1:25,000 or other convenient scale; the resulting value of d will be in the same units as D.)

H is the height of the camera lens above the horizontal datum plane. Usually, the altitude of the center of the target area is assigned arbitrarily as the horizontal datum plane and is used as the basis for distortion corrections.

d. Example of Correction for Relief Distortion (fig. 32). An aerial photograph taken at an altitude of 28,000 feet above sea level is to be used to determine the relative location of points on the firing chart. By survey, point X has been determined to be 180

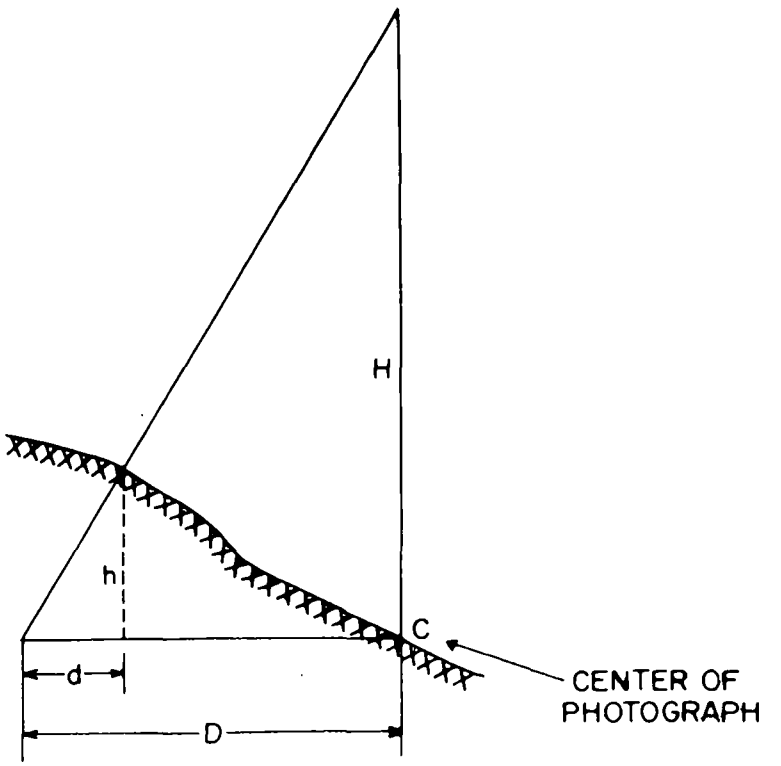


Figure 31. Determination of relief correction.

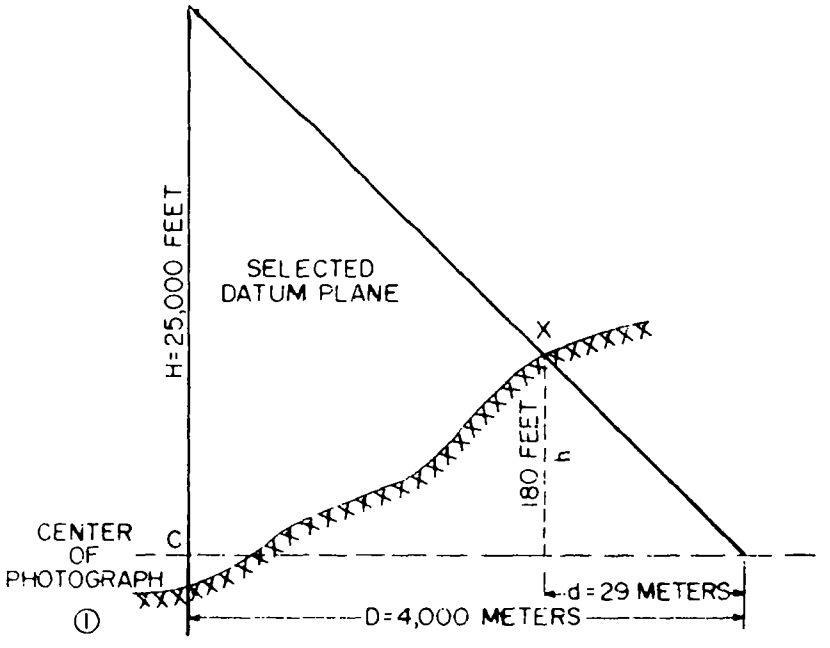


Figure 32. Example of correction for relief distortions.

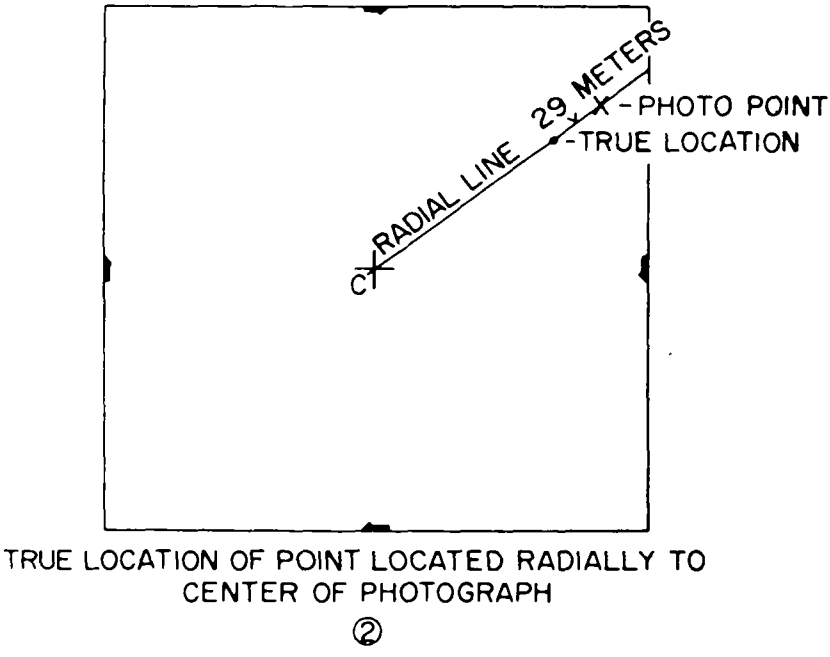


Figure 32—Continued.

feet above the registration point (1, fig. 32). The selected datum plane, based on the approximate altitude of the registration point, is 3,000 feet above sea level. Therefore, the height of the camera lens is 25,000 above the datum plane. The distance from point X to the center of the photograph is scaled as 4,000 meters. Point X will be plotted 29 meters $\left(\frac{d}{4000} = \frac{180}{25000} = 28.8 \right)$ along a radial line toward the center of the photograph from its photographic location (2, fig. 32).

Section 3. RESTITUTION

6. General

a. Restitution is the process of transferring points from aerial photograph to a chart, from one photograph to another photograph, or from a chart to a photograph. Restitution may require the use of one or more photographs, depending on the method used.

b. One of the most accurate methods of restitution is the radial line method, which requires the use of overlapping vertical photographs.

c. A single vertical photograph is used whenever the target does not appear on overlapping vertical photographs. There are four methods of restitution which involve the use of single vertical photographs only. The methods are listed in order of accuracy as follows:

(1) Alternate polar plot.
(2) Polar plot.
(3) Proportional dividers.
(4) Tracing paper resection.

d. In the restitution procedures described in paragraphs 6 through 12 of this section, critical points (photo centers, restitution points, targets, etc.) may be pricked through the photograph to a piece of overlay paper; the overlay paper may then be used in lieu of the photograph. With this procedure it will not be necessary to draw any lines on the photo except those required to locate the photo center.

7. Radial Line Method

For practical purposes, the combined effects of relief and tilt in photographs taken with a camera slightly tilted is assumed to cause displacements along radial lines passing through the centers of the photographs. This assumption is used in the radial line method of restitution to determine accurately the map position of a point appearing in the overlap of two aerial photographs taken

at different camera positions. This method of restitution will correct for both tilt and relief. However, the method is not accurate if the tilt is greater than 55 mils or if the point sought falls on or near the line joining the centers of the two photographs. (The latter condition makes it difficult to obtain a good angle of intersection.) To restitute a target which appears on two overlapping vertical photographs, the following procedure is used:

a. Mark the photo center of each photograph. The photo center, the geometric center of the photograph, is determined by the intersection of lines through the corners of the photograph or through the fiducial marks along the edges of the photograph (1, fig. 33).

b. Identify on each photograph three control points whose chart locations are known. A different set of points may be selected for each photograph, or the same points may be used. The points selected should be well out from the center of each photograph and widely distributed. Draw radial lines or rays from the center (C) of each photograph to the photographic locations of the control points (X, Y, and Z) (2, fig. 33).

c. Place tracing paper over the firing chart and prick the chart locations of the control points on the tracing paper (3, fig. 33).

d. Place the prepared tracing paper over one photograph so that the rays on the photograph pass through the corresponding control points on the tracing paper (4, fig. 33).

e. Draw a ray on the tracing paper from the center of photograph 1 through the target to be restituted (T) (4, fig. 33).

f. Repeat steps in *d* and *e* above on photograph 2 using the same tracing paper (5, fig. 33). The two photo centers and the ray from

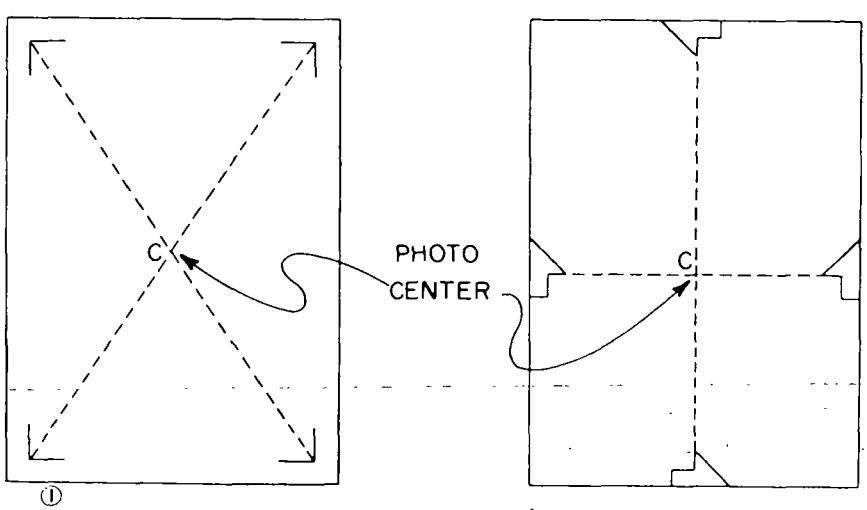


Figure 33. Radial line restitution.

each photo center to T now appear on the tracing paper. Intersection of the rays through T gives the tracing paper location of the target to be restituted.

g. Orient the tracing paper over the chart (control point over control point) and prick through the intersection of lines, thus transferring the target to the chart (6, fig. 33).

h. Another acceptable procedure for radial line restitution is one using two pieces of tracing paper, one with each photograph. The procedure for the alternate polar plot method (par. 8) is fol-

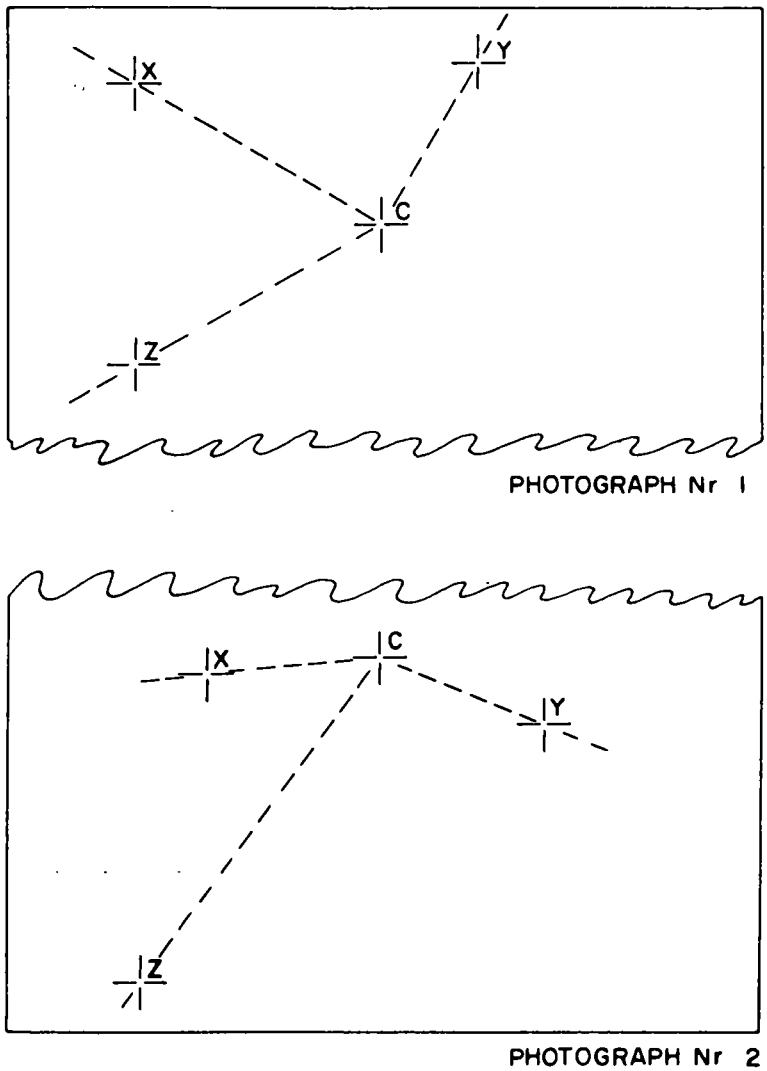


Figure 33—Continued.

lowed until both pieces of tracing paper are correctly oriented over the chart. The intersection of the two photo center-target lines (one on each piece of tracing paper) is then pricked through to the chart.

8. Alternate Polar Plot

The most accurate method of restitution from a single vertical photograph is the alternate polar plot method. This method partially eliminates errors due to distortion by using only radial lines from the photo center as bases for polar plotting. The procedure for the alternate polar plot method is as follows:

a. At least three points whose chart locations are known are identified on the photograph, and the photo center is determined and marked. Radial lines are drawn on the photograph from the photo center C to the three known points (X, Y, and Z) and the target (1, fig. 34).

b. An overlay is made from the photograph showing the photo center, and the radial lines are drawn from the center through the three points (X, Y, and Z) and the target (2, fig. 34).

c. The overlay is then placed over the chart and moved until

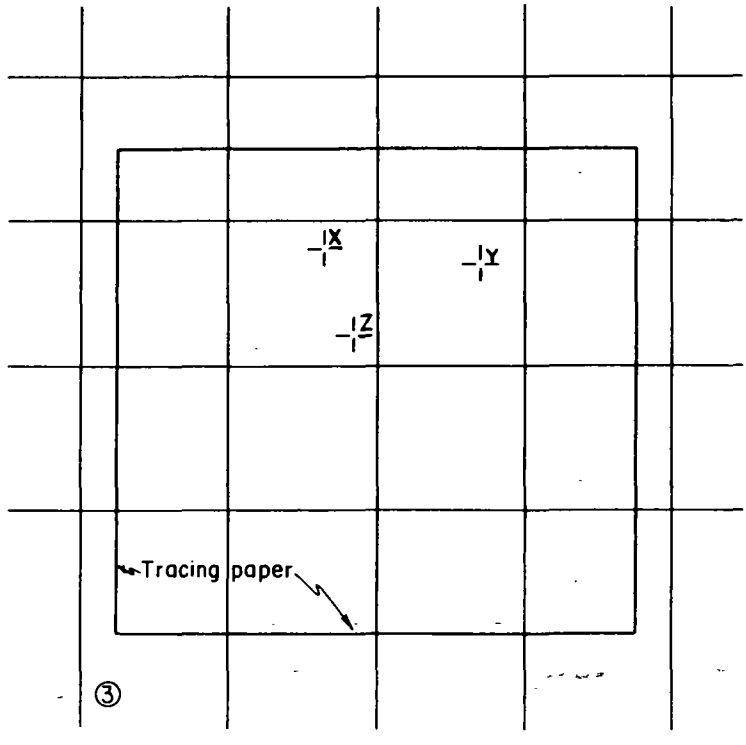


Figure 33—Continued.

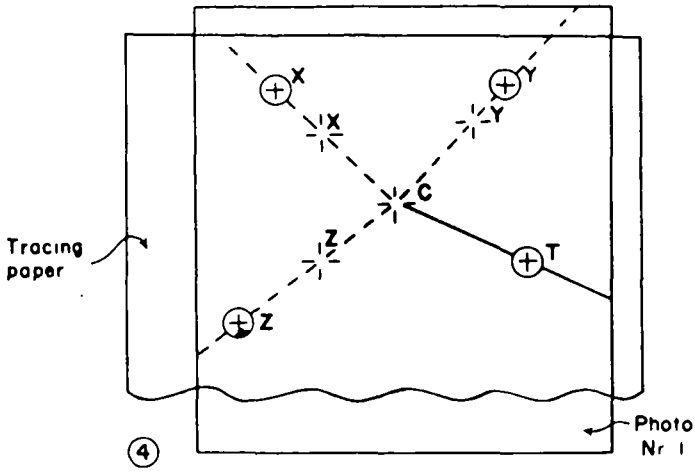


Figure 33—Continued.

the three rays pass through the control points on the chart (3, fig. 34).

d. The procedure for transferring points is as follows: Convert the photo distance to chart distance (par. 2) plot the chart distance on the ray drawn on the tracing paper from photo center to target and pinprick through the overlay paper (3, fig. 34).

9. Polar Plot

Another method of restitution from a single vertical photograph is the polar plot method. Since the angles used are not radial, in-

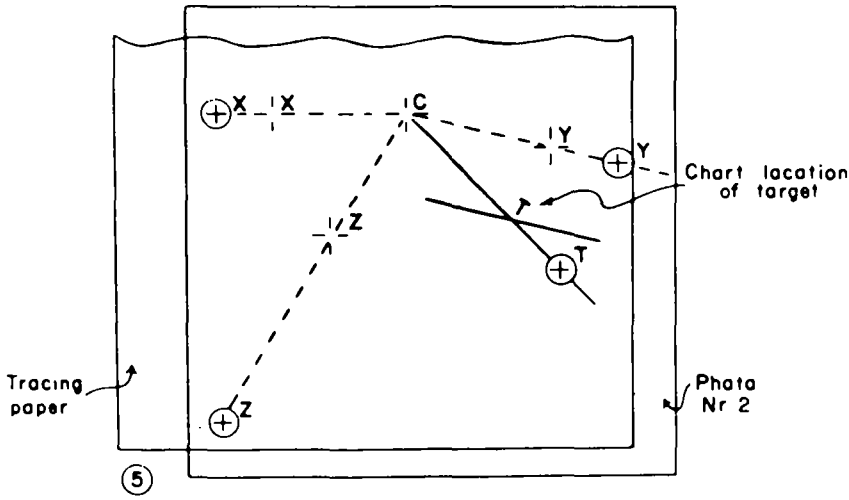


Figure 33—Continued.

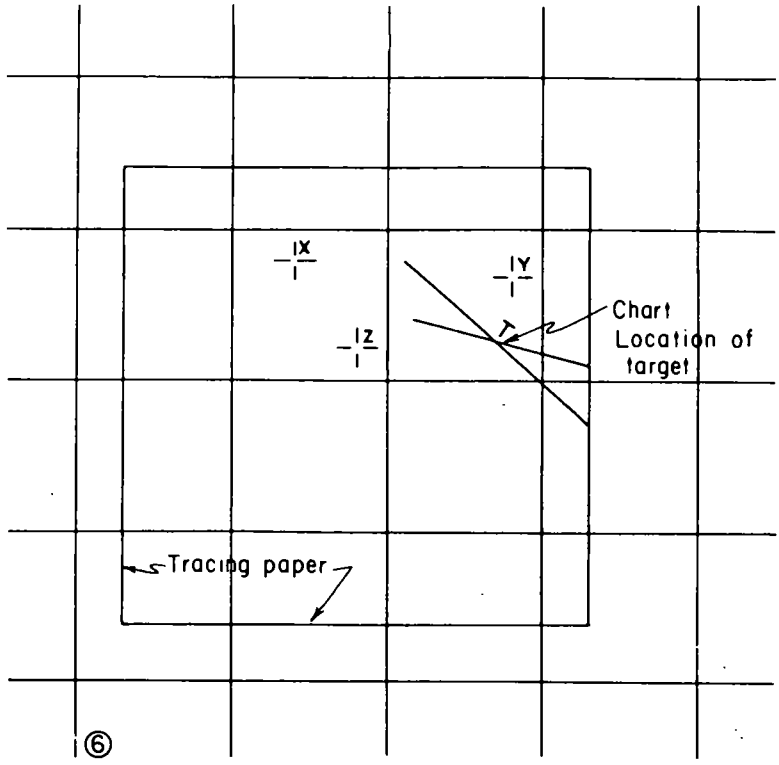


Figure 33—Continued.

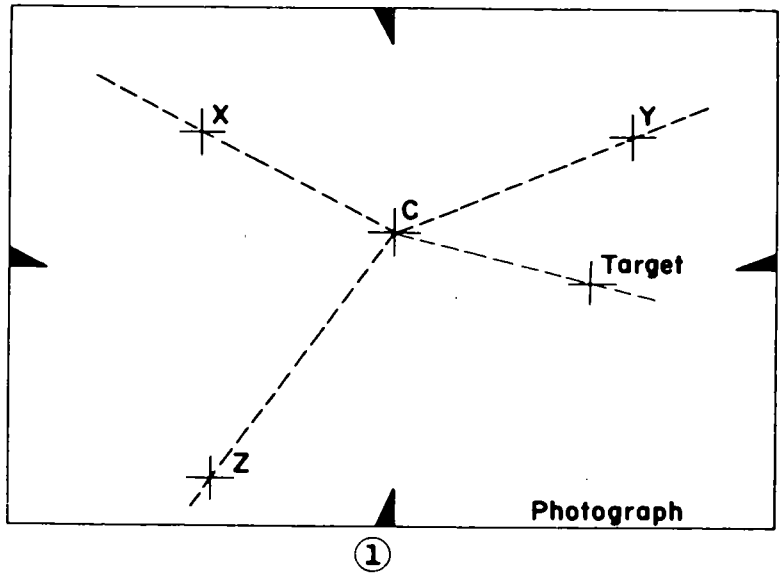


Figure 34. Alternate polar plot restitution.

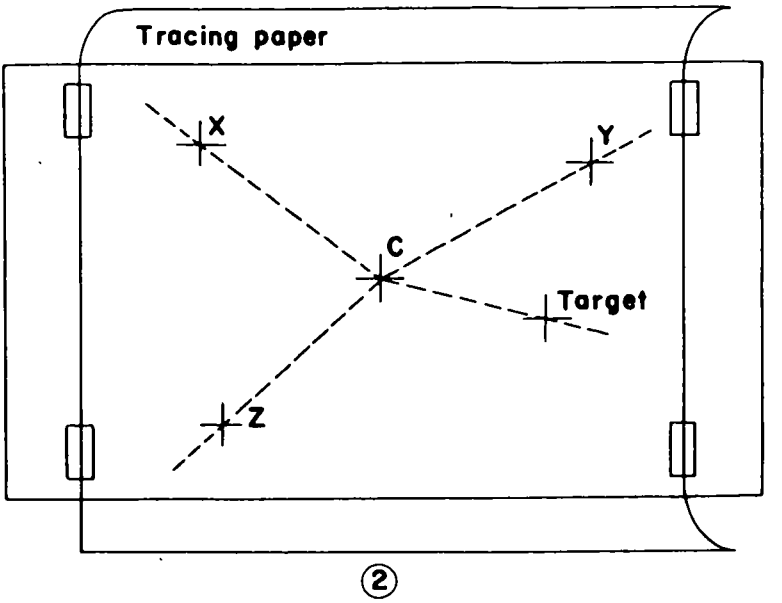


Figure 34—Continued.

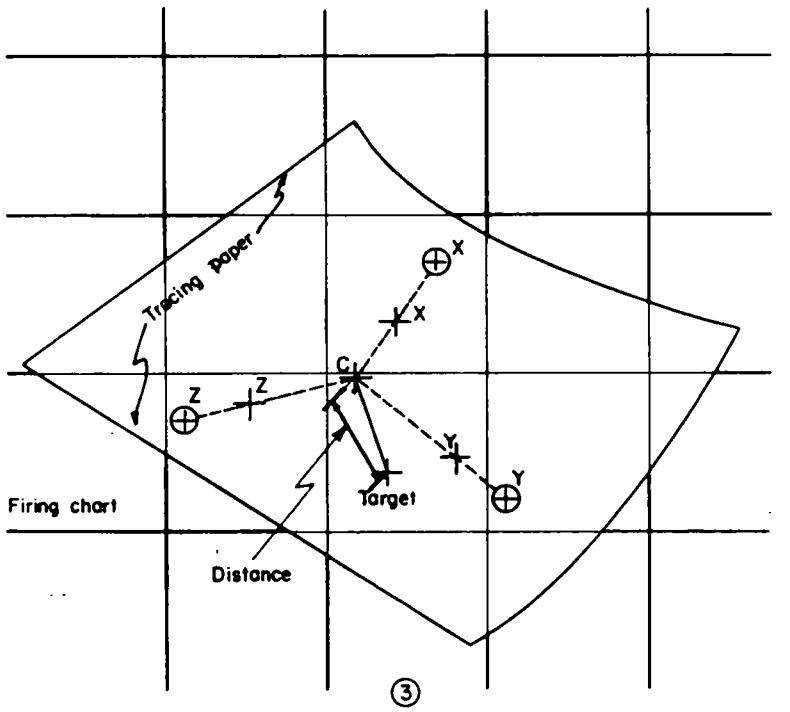


Figure 34—Continued.

accuracies from relief and tilt may be introduced. As illustrated in figure 35, the procedure is as follows:

a. Two or more well-separated points (A and B), whose chart locations are known, are identified on the photograph and a line is drawn between these two points on both the photograph and the chart. To reduce errors of relief and tilt, these points should be at about the same altitude, and the line established should pass close to the center of the photograph.

b. The line of the photograph is extended to enable distances and angular shifts to be measured from either of the points with an angle-measuring device (protractor, range-deflection protractor, or GFT fan).

c. The difference in scale between the photograph and the chart is compensated for by measuring the photograph and chart distances and by setting up a relation between the two on a slide rule (par. 6). In the example shown in figure 41, photo distance

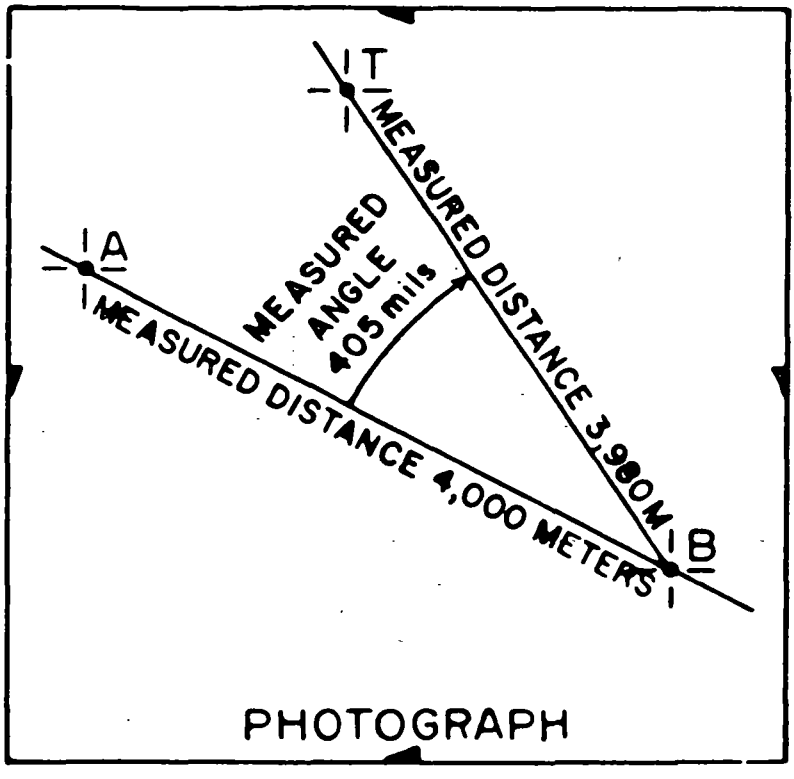


Figure 35. Polar plot restitution.

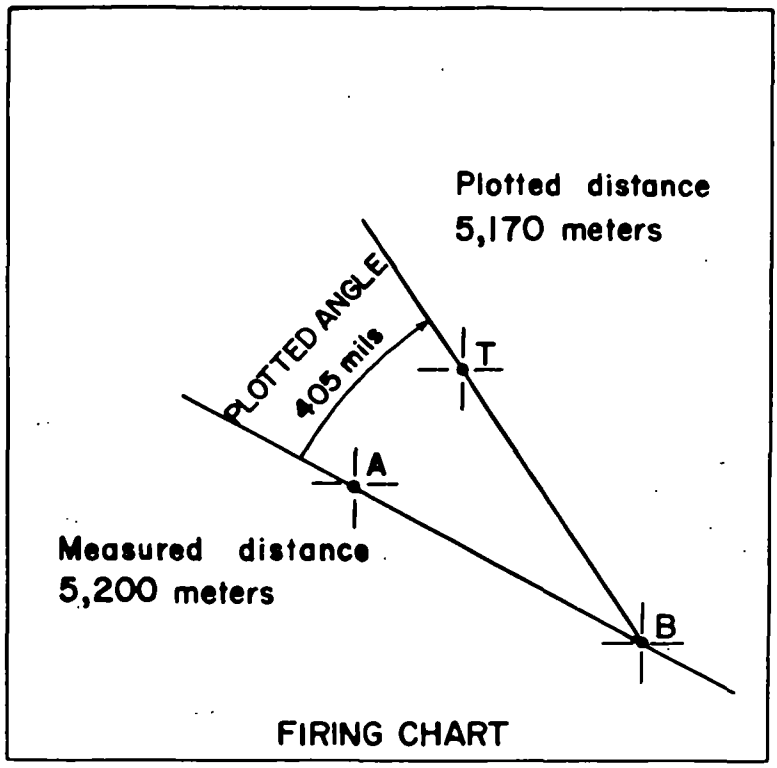


Figure 35—Continued.

(4,000 meters) is placed on the C scale over chart distance (5,200 meters) on the D scale.

d. To restitute a point (T) from the photograph to the chart, the angular shift from the known line and the distance are measured from the known point that will give the smallest angle and the largest distance. In this case, the measurement is made from point B, and the results are an angular shift of 405 mils right of line BA and a photo distance of 3,980 meters.

e. The photo distance is converted to chart distance by using the relationship set up on the slide rule and the procedure described in paragraph 6 this appendix. By moving the hairline to the photo distance of 3,980 meters on the C scale, the chart distance of 5,170 meters is read directly below it on the D scale.

f. Point T is plotted on the chart by using the measured shift of 405 mils right of line BA and the chart distance of 5,170 meters from point B.

10. Proportional Dividers

The most rapid method of restitution is by the use of proportional dividers (fig. 36). This instrument consists of two legs, each pointed at both ends, which are held together by means of a central pivot. When the legs are opened in the form of an X, either end of the instrument forms a pair of ordinary dividers. The position of the pivot along the legs can be varied to produce any desired ratio. Once the pivot of the dividers is set to the proper photograph-chart ratio, all points on any particular photograph may be restituted to the chart without disturbing the adjustment of the pivot. With the pivot at a fixed setting, distances are taken off the photograph with one end of the proportional dividers and laid off on the chart with the other end. These photo distances, however, are subject to errors of tilt and relief. To restitute points from photograph to chart, proceed as follows:

a. Select restitution points which appear on both the photograph and the chart. In figure 36, the two points selected are the bridge and the fence corner.

b. By trial and error, adjust the pivot so that, when the points on the photograph end of the dividers match the two restitution points on the photograph, the points on the chart end of the dividers will match the two restitution points on the chart.

c. Using the photograph ends of the dividers (fig. 36), lay off the distance from the first restitution point to the point to be located. Without disturbing the adjustment, reverse the dividers and strike an arc on the chart from the first restitution point in the direction of the point to be located (fig. 36).

d. Repeat the procedure for the second restitution point. The location of the point on the chart is at the intersection of the two arcs drawn. If a third restitution point is available, another arc is drawn to give a check on the location determined from the first two.

11. Tracing Paper Resection

a. Points within a limited area appearing on a vertical photograph may be plotted roughly on a map or firing chart by means of tracing paper resection.

b. To locate a point (P) (fig. 37), identify on the photograph at least three points (preferably five) that appear on the map or firing chart. Mark on a sheet of tracing paper the photographed position of these points and the point to be located. This is accomplished best by tacking the photograph over the tracing paper and pricking a pin through each point. On the tracing paper, draw rays from the point (P) to each of the known points, such as a, b, c, d, and e. Place the tracing paper on the map or chart so that

Figure 36. Restitution with proportional dividers.

the ray to each of the known points passes through the map or chart location of the corresponding point. The point (P), represented by the intersection of rays, is then in its relative position to the known points, and its position may be pricked onto the map.

c. The tracing paper resection method is subject to errors of tilt and relief. The error of location can sometimes be reduced by selecting more than the minimum of three known points. Accuracy can be improved by selecting restitution points that are widely separated and are near the altitude of the mean datum plane.

12. Vertical Control

Normal methods of restitution do not include adequate means of determining vertical control. Use of a stereoscope may aid in determination or relative heights. High obliques, when gridded, can be used to supplement vertical control. If a map is available and points can be identified on both the map and photograph, vertical control is relatively simple. A pantograph (TM 5–230) can be used, if available, to transcribe contour lines from a map to a vertical photograph. Vertical control can also be established

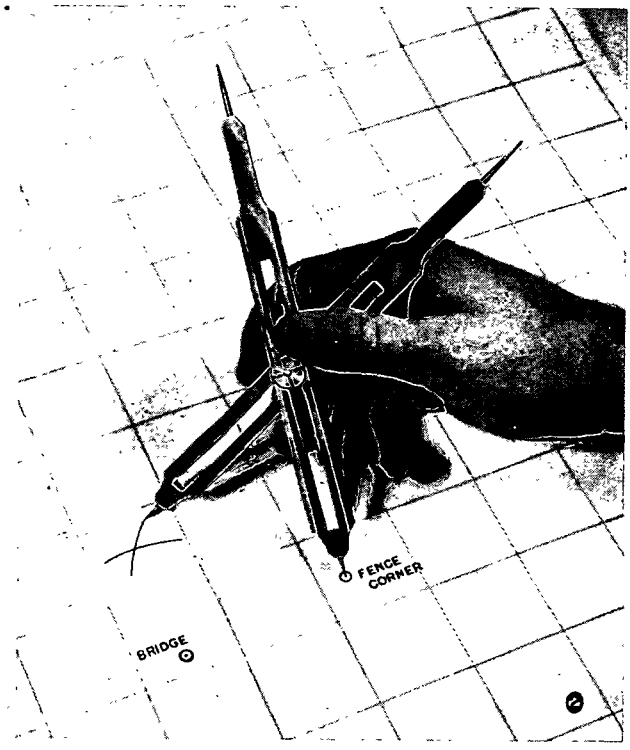
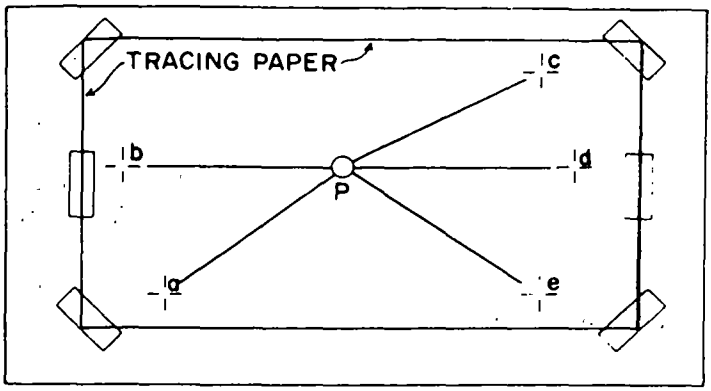
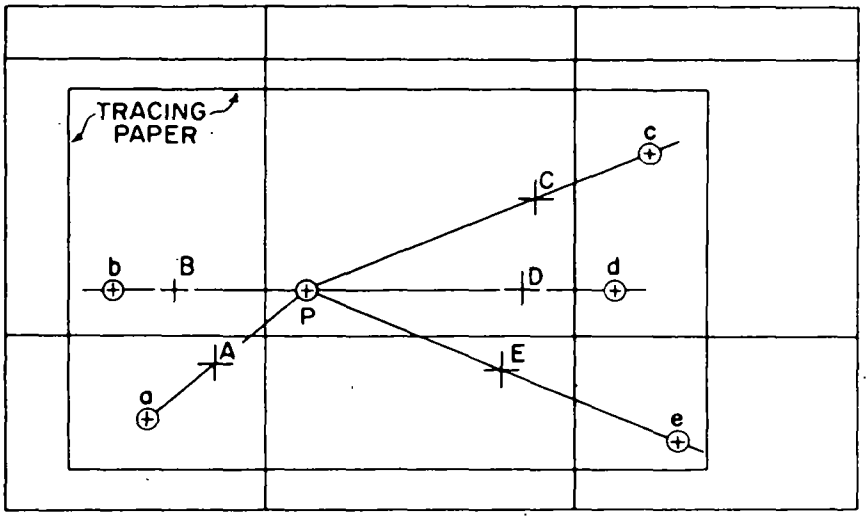


Figure 36—Continued.

provided known points are on terrain which is accessible, or visible, to the survey party.



① PHOTOGRAPH



② TRACING PAPER OVERLAY

Figure 37. Tracing paper resection.

Section 4. OBLIQUE PHOTOGRAPHS

13. General

Oblique photographs are those taken with the axis of the camera intentionally tilted from the vertical position. Oblique photographs which show the horizon are high obliques and those which do not show the horizon are low obliques.

14. Characteristics

The primary characteristics of oblique photographs are as follows:

a. Oblique photographs may be taken from either air or ground observation posts.

b. Oblique photographs can be taken with an ordinary camera.

c. Relief is more readily recognizable on an oblique photograph than on a vertical photograph.

d. Oblique photographs are limited by their size and perspective to a useful depth of about 10,000 meters.

15. Uses

Oblique photographs are used for the following purposes:

a. Reconnaissance. Oblique photographs are used to supplement visual reconnaissance; they present to the commander a view of the terrain similar to that observed by an observer in a frontline position.

b. Briefing. Oblique photographs are used to brief ground and air observers and to designate objectives, phase lines, boundaries between units, zones of fire, zones of observation, and observation posts.

c. Terrain Sketches. Observers can use oblique photographs as terrain sketches. When a copy of the photograph is available to the fire direction center, it facilitates the exchange of battlefield information and enables the S3 and S2 to see the terrain as the observer sees it.

16. Mil-Gridded Oblique Photographs

a. Mil-gridded oblique photographs (fig. 38) are made by the Air Force by contact printing the negative through a transparent mil grid. Mil-gridded oblique photographs are used in conjunction with firing charts to determine the horizontal and vertical locations of given points (fig. 39). However, the horizontal locations of points obtained from gridded oblique photographs are not so accurate as those obtained from vertical photographs. Therefore, oblique photographs should not be used to determine horizontal locations when vertical photographs are available. Gridded oblique photographs, however, may be used to good advantage in conjunction with firing charts to determine altitude.

b. The following terms are used in conjunction with mil-gridded oblique photographs:

(1) *Plumb point*—The point on the ground directly beneath the perspective center of the camera lens.

(2) *Center line*—The map projection of the vertical plane that contains the axis of the camera at the instant the

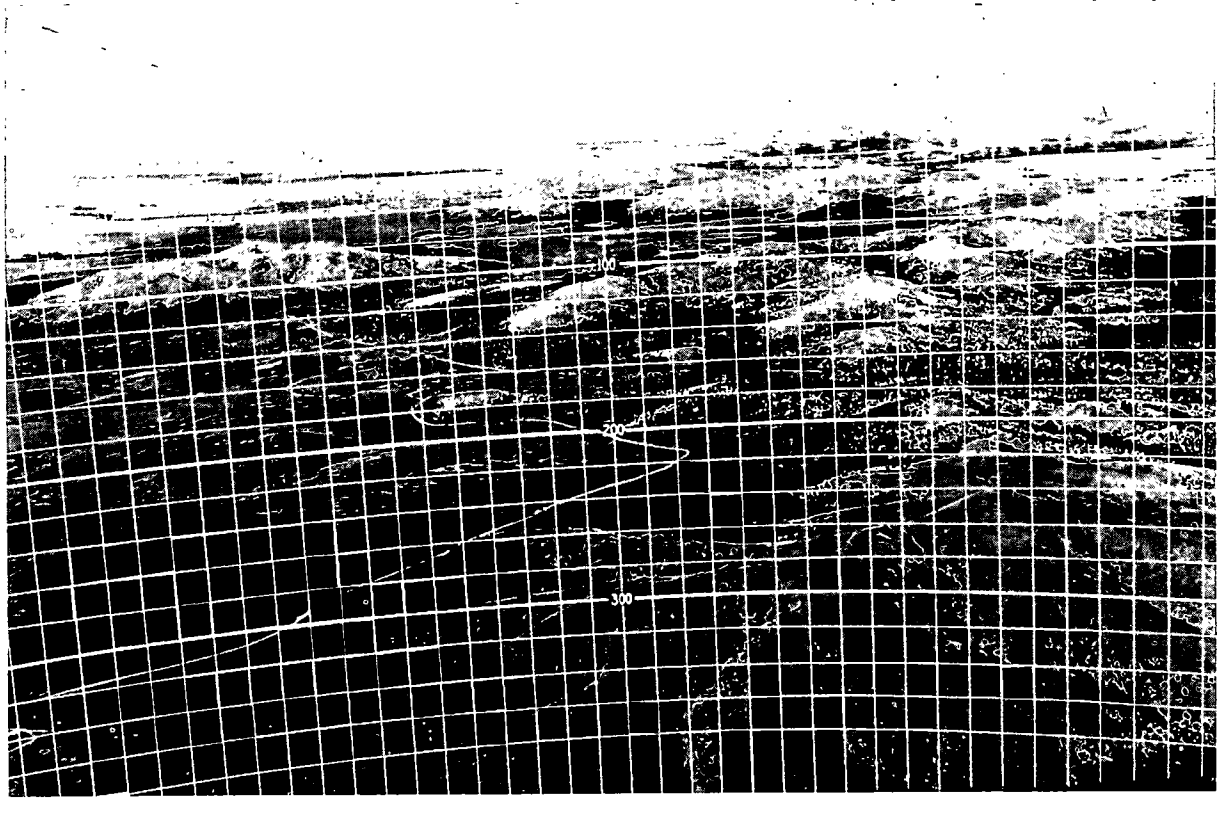


Figure 38. Mil-gridded oblique photograph.

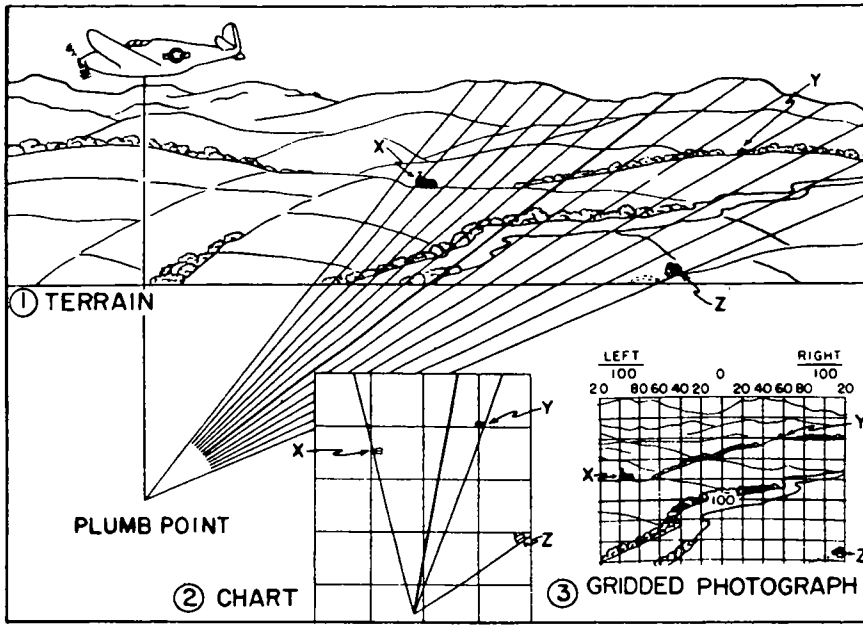


Figure 39. Mil-gridded oblique photograph used in conjunction with firing chart.

photograph was taken. On the photograph, the center line appears as the zero line from which right and left angular measurements are taken. On the chart, the center line appears as the direction line from which the right and left angular measurements are plotted.

17. Horizontal Locations

a. Orientation of Photographs. Oblique photographs are oriented by determining the chart locations of plumb points and the chart direction of center lines.

(1) *Location of plumb points.* The tracing paper method of resection can be used to determine the chart locations of plumb points. The chart locations of three or more ground control points appearing on each photograph are necessary. These chart locations may be determined by survey or may be taken from a map or vertical photograph. The relative locations of the ground control points on the observed firing chart may be determined by firing. In preparing the tracing paper to be used in the resection, the horizontal angle from the center line to each ground control point is read on the mil grid and plotted on the tracing paper with an angle-measuring device. The tracing paper then is placed over the chart in such a

position that the ray toward each control point passes through the chart location of the same point. The plumb point is pricked through to the chart.

(2) *Location of center lines.* With the tracing paper in the same position as in (1) above, any convenient point on the center line is pricked through to the chart.

Note. Each plumb point and center line must be labeled with its photograph number; center lines are also marked with identifying arrows.

b. Transposition of Points from Oblique Photographs to Charts.

(1) *Point designation.* Oblique photograph references include a photograph number and horizontal and vertical angles; for example, "Photo 58, L156042." The photograph number designates the photograph from which the reading was taken. The letter "L" or the letter "R" indicates a reading left or right of the center line. The first three figures represent the horizontal angle from the center line. The last three figures represent the vertical angle from the 0 or level line.

(2) *Plotting the point.* Points are located from oblique photographs by plotting the intersection of two or more lines of sight.

Example: The following message has been received from an observer: PHOTO 59, R210118, INFANTRY PLATOON WITH HEAVY WEAPONS, REQUEST BATTALION, FIRE FOR EFFECT. Fire direction personnel identified the same point on photograph 60 as L060 and on photograph 61 as L305. The target should be plotted as in figure 40.

18. Determination of Altitudes

When mil-gridded oblique photographs are used in conjunction with maps having suitable vertical control, map altitudes are used. If maps are not available, the altitude of the camera is computed and then the vertical interval between the camera and the target is subtracted from the altitude of the camera.

a. Altitude of the Camera. To determine the altitude of the camera, it is necessary to have one point which can be identified on the photograph and of which the chart location and altitude are known. The vertical interval between the selected point and the camera is determined by using the mil relation. The interval plus the known altitude of the point is the altitude of the camera. For example, a house, the altitude of which has been established by survey, appears at a vertical angle of 100 mils on photograph 59.

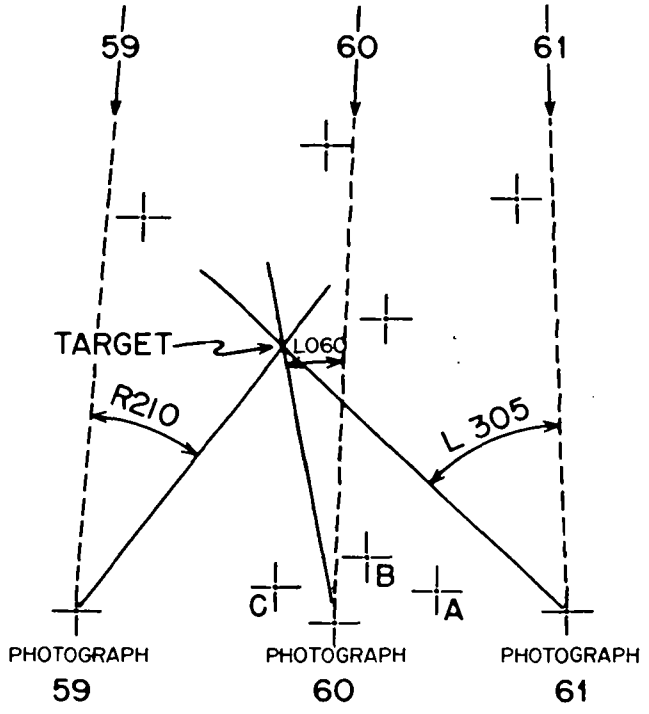


Figure 40. Location of a target on the firing chart.

The distance on the firing chart from the house to the plumb point of photograph 59 is 3,500 meters. Figure 41 shows the relations that exist.

Vertical interval (3.5 × (+100))	=	+350 meters
Altitude of house (survey)	=	300 meters
Altitude of camera (350 + 300)	=	650 meters

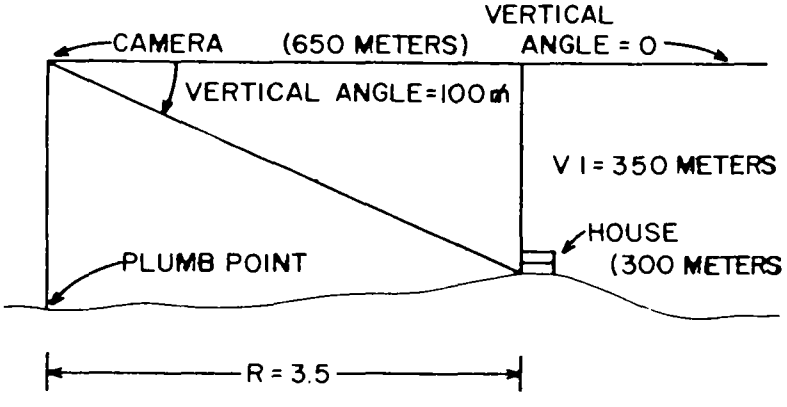


Figure 41. Determination of the altitude of the camera.

b. Altitude of the Target. The altitude of a target cannot be determined from a mil-gridded oblique photograph until the altitude of the camera has been established. When this altitude has been established, the altitude of any target is determined by subtracting the vertical interval between the target and the camera from the altitude of the camera. For example, a target is reported by reference to an oblique photograph, as PHOTO 59, R210118, chart distance, after plotting, from the plumb point to the target is 3,200 meters.

Altitude of camera (a above)	=	+650 meters
Vertical interval ($3.2 \times (-118)$)	=	−378 meters
Altitude of target ($650 - 378$)	=	272 meters

APPENDIX V

TARGET ACQUISITION SYSTEMS FACT SHEETS

Section 1. AIRCRAFT

1. General

Aircraft are used to search areas defiladed from ground observation and to increase the depth of observation.

DRONE SYSTEM AN/USD–1

a. AN/USD–1 Surveillance Drone (fig. 42).

Speed	184 (sea level).
Operational Range	40 miles (65 km).
Endurance	30 minutes (sea level).
Engine type	two-cycle, air-cooled.
Number of cylinders	4.
Rated horsepower	72 at 4,100 rpm.
Power supply	28 volt DC nickel-cadmium battery.
Wing span	161.265 inches (with pods).
Length	160.863 inches.
Weight (less camera)	400 pounds.
Useful load	40 pounds.

b. Employment of Drone System AN/USD–1. The AN/USD–1 drone (fig. 50) is a radio controlled, unmanned aircraft designed to provide identification and location of targets by means of aerial photography. It has an operational range of 65 kilometers. The camera used in the SD–1 can take up to 95 aerial photographs on command from the ground. Targets can be restituted from these photographs with an accuracy of 20 to 80 meters. Recovery of the drone is accomplished by means of a parachute. The drone system includes 12 AN/USD–1 drones, each complete with a camera, beacon, and flare ejectors; two complete ground control stations; three portable zero-length launchers; three hydraulic engine starters; one electronic maintenance van; four drone-handling trucks; and other equipment necessary for the transport, maintenance, and launch of the drones. The drone platoon is authorized two AN/MPQ–29 tracking and plotting radars which are used to indicate the position of the drone. The drone section, organic to division aviation general support company, utilized the two AN/MPQ–29's

organic to the guidance and control section. A mobile photographic darkroom is also authorized. Since the drone is launched from a zero-length portable launcher and is recovered by parachute, it can be operated in varied types of terrain. Prior to launch, the controller places his flight plan on a standard scale map mounted on a plotting board in the radar van. After launch, the controller moves into the radar van where the position of the drone is shown by a trace on the map. After the drone is airborne and the AN/MPQ–29 tracking and plotting radar has locked onto it, the controller flies his mission by radar plot. An altimeter indicates the drone's altitude, thus enabling the controller to insure that the drone is at the proper altitude over the target. The height of the drone over the target determines the scale of the resultant photograph. This height is set on the camera prior to launch at one of six different settings from 400 feet to 4,000 feet. All photographs taken on one mission must, therefore, be photographed from the same height above ground. The total average time from request of a mission to the completion of the print is approximately 1 hour and 15 minutes. The drone is capable of taking ten night photographs per mission by using the KA–39A day-night camera with photo flash cartridges ejected from the drone on command from the ground.

c. AN/MPQ–29 Radar (fig. 43).

Frequency	9400 megacycles.
Range:	
Maximum beacon track	92 kilometers.
Maximum skin track	22 kilometers.
Accuracy	+20 meters.

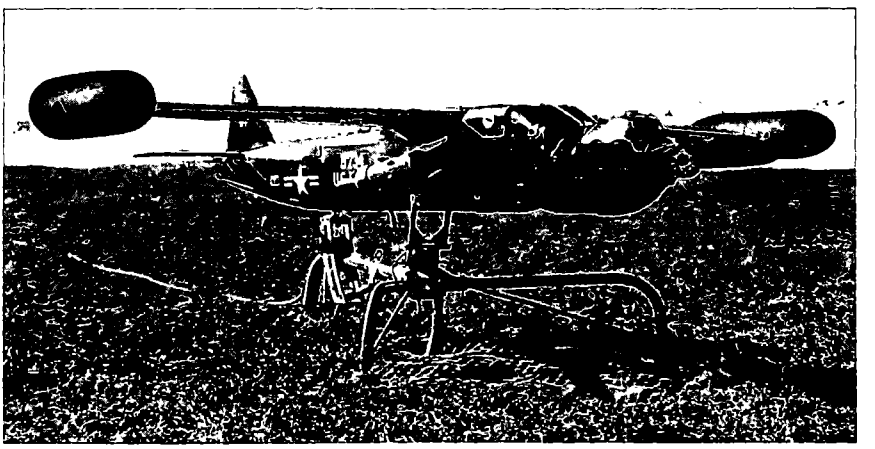


Figure 42. Drone AN/USD–1.

Azimuth:	
Coverage	6400 mils.
Accuracy:	
Radar	2 mils.
Beacon	1 mil.
Elevation:	
Coverage	−175 to +1,550 mils.
Accuracy:	
Radar	2 mils.
Beacon	1 mil.
Setup time	20 minutes by a crew of four trained men.
Power requirements	3 kilometers, 115 volts, 60 cps, 3-phase.

d. KA–20A Still Picture Camera (fig. 44).

(1) *General characteristics.*

Weight	25 pounds.
Shutter speeds	1/150 and 1/300 second.
Film accommodated type	Aerial roll film, 9.5 inches wide by 75 feet long.
Format	9 by 9 inches.
Exposures per roll	95.

Figure 43. Radar set AN/MPQ–29.

Lens:

Type	Metrogon (wide angle).
Focal length	6 inches.
Opening	f/6.3 (fixed).
Angle of field	90°.

(2) *Image motion compensation control settings.*

IMC control setting	*Photo scale*	*IMC rate (in/sec)*	*Cycle internal time (sec)*	*Total running time (min)*
400	1/800	4.4	.8	1.3
800	1/1600	2.2	1.6	2.6
1500	1/3000	1.2	3.1	4.9
2000	1/4000	.9	4.1	6.5
3000	1/6000	.6	6.1	9.7
4000	1/8000	.4	8.2	13.0

e. KA–39A Still Picture Camera (fig. 45).

(1) *General characteristics.*

Weight	35 pounds.
Shutter speeds	1/150 and 1/300 second.
Film accommodated type	Aerial roll film, 9.5 inches wide by 75 feet long.

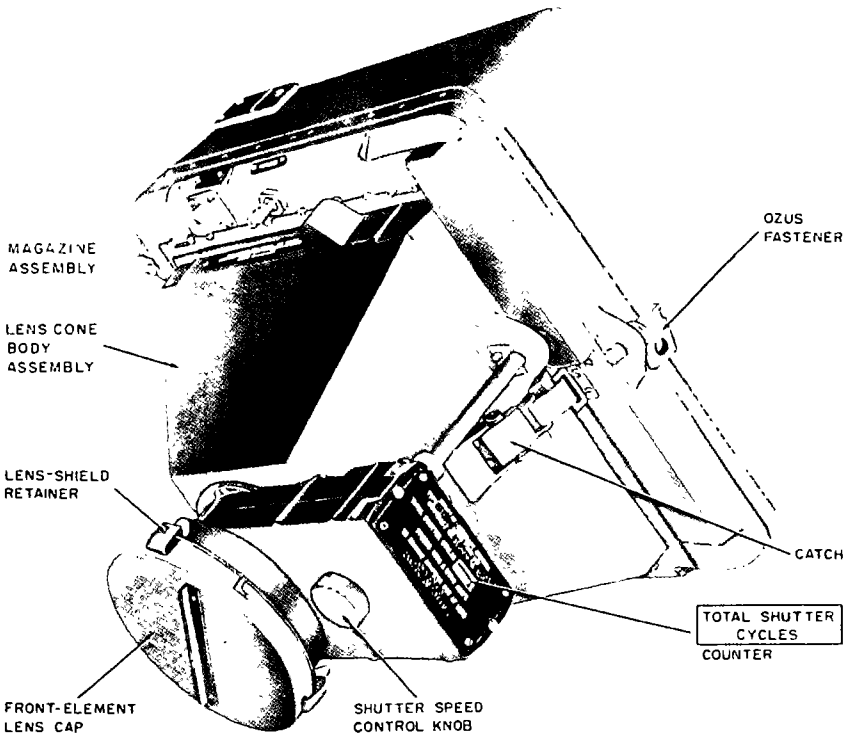


Figure 44. Camera, Still Picture, KA–20A.

Format	9 by 9 inches.
Exposures per roll	95.
Lens:	
Type	Metrogon (wide angle).
Focal length	6 inches.
Opening	f/6.3 (fixed) usable to F/4.
Angle of field	90°.

(2) *Image motion compensation control settings.*

IMC Control setting 200 mph aircraft	*Photo scale*	*Cycle internal time (sec)*	*Film consumption rate (FPM)*
1,000	1/2,000	2.0	20.37
1,500	1/3,000	3.2	13.56
2,000	1/4,000	4.0	10.19
2,500	1/5,000	5.5	8.15
3,000	1/6,000	6.25	6.79
4,000	1/8,000	8.0	not available
5,000	1/10,000	11.0	4.07

f. H–13, Sioux.

The H–13 single-engine helicopter incorporating a two-blade main rotor and two-blade tail rotor with conventional control

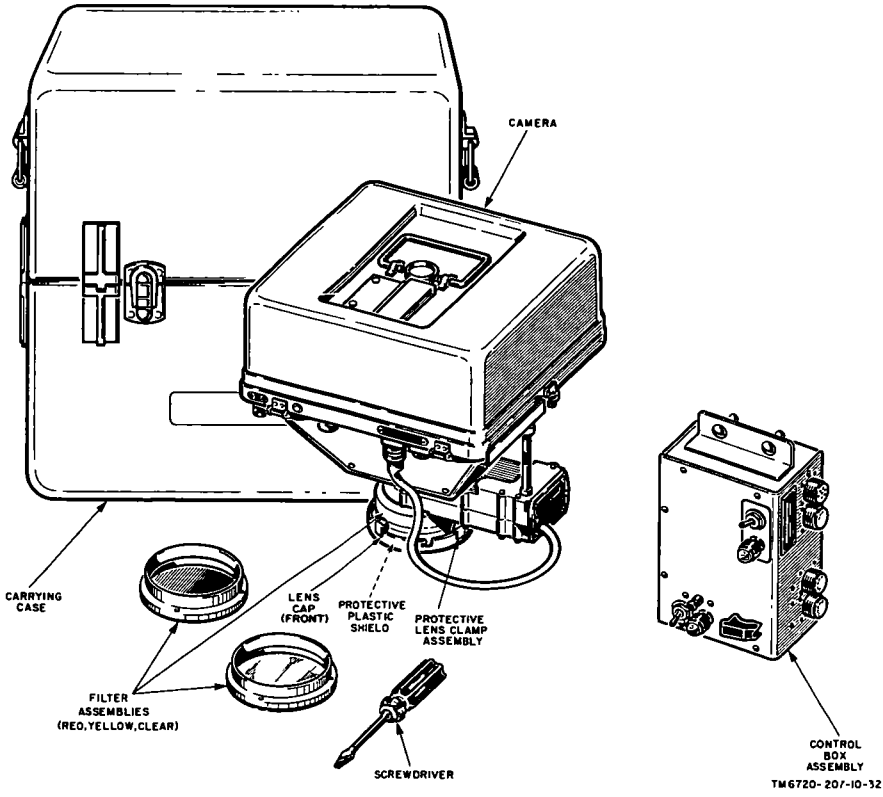


Figure 45. Camera, Still Picture KA–39A.

system, is the army's standard observation helicopter. It is used extensively by combat units for reconnaissance, emergency medical evacuation, command liaison, wire laying, and resupply in the combat zone and in training. It has an open configuration fuselage with a bubble cockpit, skid landing gear with ground handling wheels installed, and provisions for attaching two litter pods on the landing gear cross tubes outside the aircraft. The H–13 helicopter carries a pilot and passenger inside or a pilot inside and two litter patients on the litter mounted on the landing gear cross tubes. Its speed is 59 knots and its range 200 kilometers. It is powered by a vertically mounted six-cylinder, horizontally opposed piston engine. The H–13 has a rotor diameter of 35.1 feet; it is 41.4 feet long, 9.5 feet high, and 8.6 feet wide (fig. 46). The aviation section headquarters and headquarters battery, division artillery, is authorized 10 of these aircraft.

g. L–19A, Bird Dog. A single engine fixed wing aircraft used by the army as its standard fixed-wing light observation aircraft. It is equipped with flaps, fixed landing gear, and steerable tail wheel to permit maximum efficient operation from small, unimproved landing fields. The Bird Dog has a speed of 86 knots and a range of 640 kilometers. It is powered by a 6-cylinder horizontally opposed piston engine, has a wing span of 36 feet, is 25 feet long and 9.2 feet high. The L–19A carries a pilot and one passenger (fig. 47) and may employ a KA–20A camera.

h. AO–1 Mohawk. The medium observation aircraft AO–1 Mohawk (fig. 48), is a twin engine, fixed wing aircraft with a cruising

Figure 46. Helicopter H–13 Sioux.

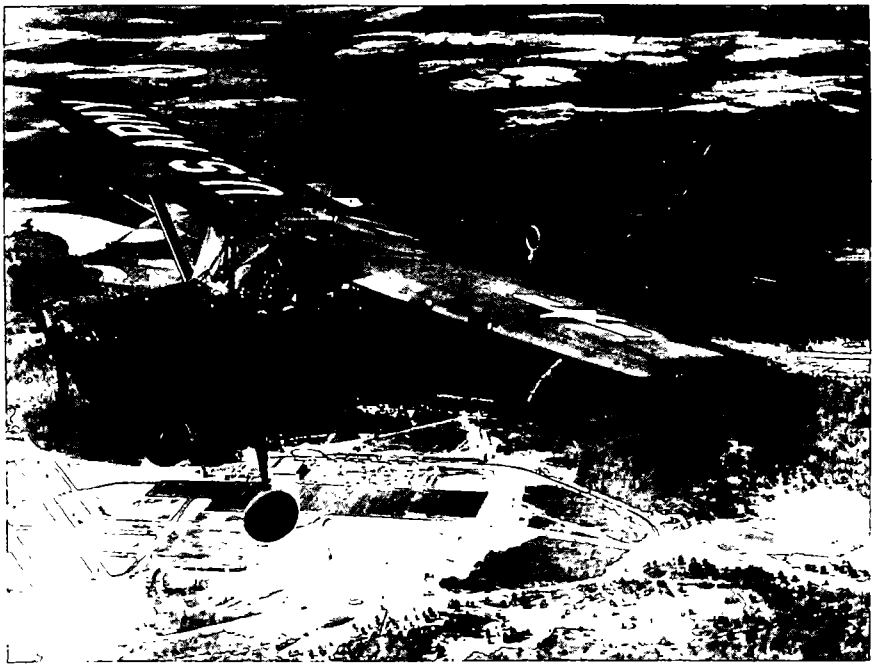


Figure 47. The L–19A, Bird Dog, primarily an observation aircraft.

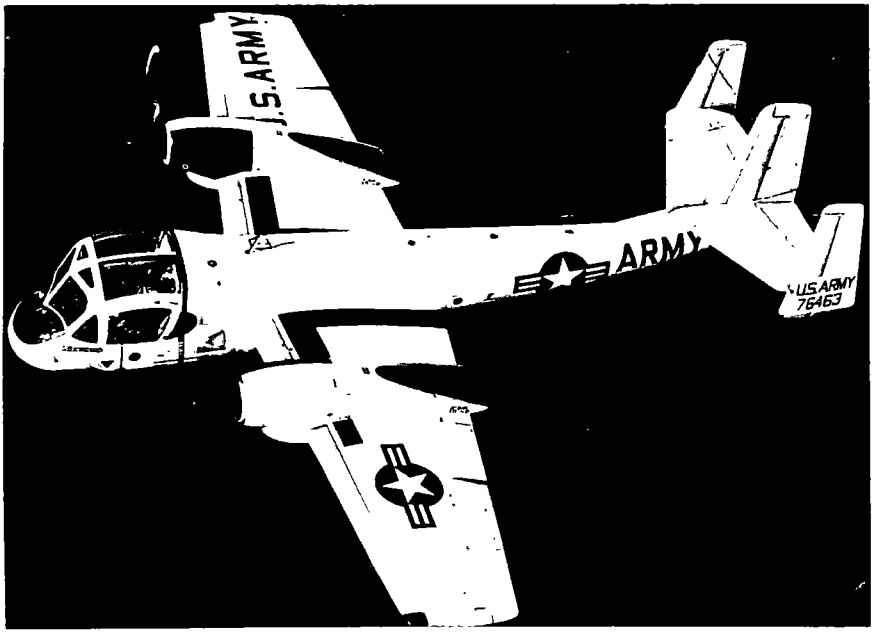


Figure 48. The observation aircraft AO–1 Mohawk.

speed in excess of 200 knots and a service ceiling of over 25,000 feet. It is primarily an observation aircraft, capable of carrying a pilot, an observer, and electronic and aerial camera equipment. Four AO–1 aircraft are assigned to the aerial surveillance and target acquisition platoon, aviation general support company, aviation battalion of all divisions—two in the aerial radar section (each equipped with the side-looking aerial radar system AN/APS–94) and two in the aerial infrared section (equipped with the infrared detector system AN/UAS–4). In addition, each aircraft in these flights will carry a KA–30 aerial camera.

Section 2. FLASH RANGING EQUIPMENT

2. Telescope, Observation, Periscope, T9

a. Purpose. The T9 observation telescope (fig. 49) is used by flash ranging platoons to locate targets by visual observation and intersection from two or more OPs. Flash ranging can be used for—

(1) Location of hostile artillery.
(2) Registration and adjustment of friendly artillery.
(3) Collection of battlefield information.
(4) Comparative calibration of friendly artillery.
(5) Verification of the location of friendly nuclear bursts.

b. Technical Characteristics.

Weight with ground-shelf mount	31 pounds.
Weight with universal tripod	38 pounds.
Weight of complete instrument with carrying case and accessories	39 pounds.
Magnification	10X.
Alternate magnification	20X.
Horizontal and vertical scales	Direct reading to 1 mil; interpolation to 0.2 mil (internal scale).
Vertical angle capability	−500 to +800 mils.
Internal lighting system	Yes.
Leveling	Three screw.
Magnetic compass	Tubular.
Field of view	10X—107 mils horizontal, 74 mils vertical; 20X—53 mils horizontal, 37 mils vertical.

c. Reference. To be published.

d. Technical Characteristics of Flash Platoon.

Operating range	Up to range of visibility (approximately 15,000 meters).
Accuracy	0 to 50 meters.
System elements	Observation posts and command post.
Communication link	Primary: Wire. Secondary: Radio.

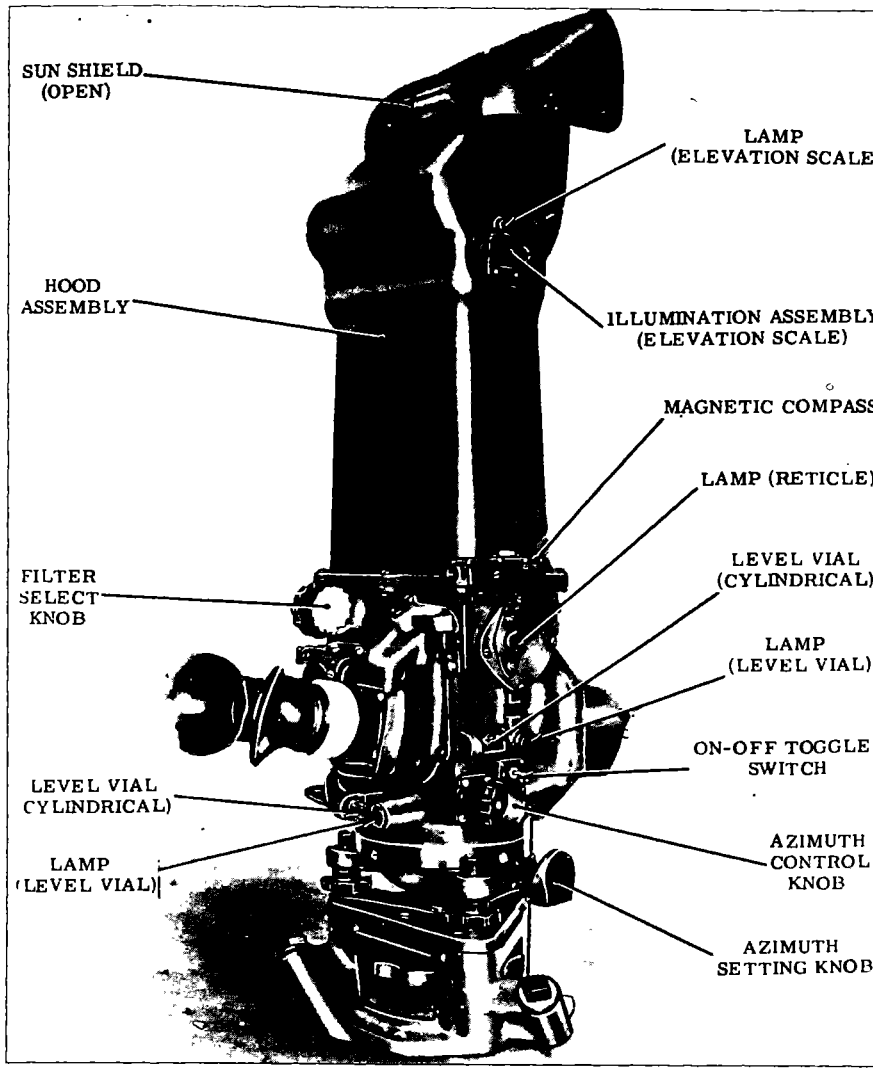


Figure 49. Spotting Instrument T9.

e. Reference.

(1) FM 6–122, Artillery Sound Ranging and Flash Ranging.
(2) TM 11–5516, Flash Ranging Set, AN/GTC–1.

Section 3. METEOROLOGICAL EQUIPMENT

3. Radiosonde AN/AMT–4

a. Purpose. The radiosonde AN/AMT–4 (fig. 50) is a meteorological instrument which is carried aloft by a sounding balloon to obtain soundings of the temperature, pressure, and relative hu-

midity of the upper atmosphere. This instrument automatically transmits radio-frequency signals, amplitude modulated at a frequency that varies in accordance with the conditions of temperature and humidity of the atmosphere encountered during the flight. A baroswitch connects the circuits of the transmitter successively, so that a repeating sequence of temperature, humidity, and reference signals are transmitted. These data are used in calculating corrections to compensate for the effects of nonstandard meteorological conditions for artillery fire.

b. Technical Characteristics.

Frequency range	1600 to 1700 megacycles.
Type of signal	Amplitude modulated.
Type of antenna	Dipole.
Power source	Water activated battery pack.
Atmospheric pressure range	1060 to 5 millibars.
Temperature range	+60° to −90° Celsius.
Relative humidity	10 to 100 percent.
Effective altitude	32 kilometers.
Effective range	210 kilometers.

c. Reference. TM 11–2432A, Radiosondes AN/AMT–4A, AN/AMT–4B, AN/AMT–4C, and radiosonde set AN/AMT–4D.

4. Rawin Set AN/GMD–1

a. Purpose. The rawin set AN/GMD–1 (fig. 51) is a transportable radio-direction finder which automatically tracks a radiosonde, tunes itself to the transmitted frequency, and records angles to the radiosonde at a maximum rate of 10 times each minute. The emitted radiosonde signal contains meteorological data in the form of audio modulation which is received, amplified, and detected by the rawin equipment. Recordings of time versus progressive changes of elevation and azimuth positions of the radiosonde are made by the control recorder. These readings are later converted to windspeed and direction. A separate piece of equipment, the radiosonde recorder, records the meteorological information which is then converted to values of temperature, humidity, and pressure.

b. Technical Characteristics.

Frequency range	1660 to 1700 megacycles.
Type of reception	AM or FM.
Power requirements	1,000 watts; 105–129 volts; 50–65 cps.
Type of antenna	Single dipole.
Type of reflector	Parabolic.
Type of scan	Conical.
Type of receiver	Superheterodyne.
Frequency control	Automatic or manual.
Approximate tracking accuracy	0.05°.
Effective altitude	32 kilometers.
Effective range	210 kilometers.

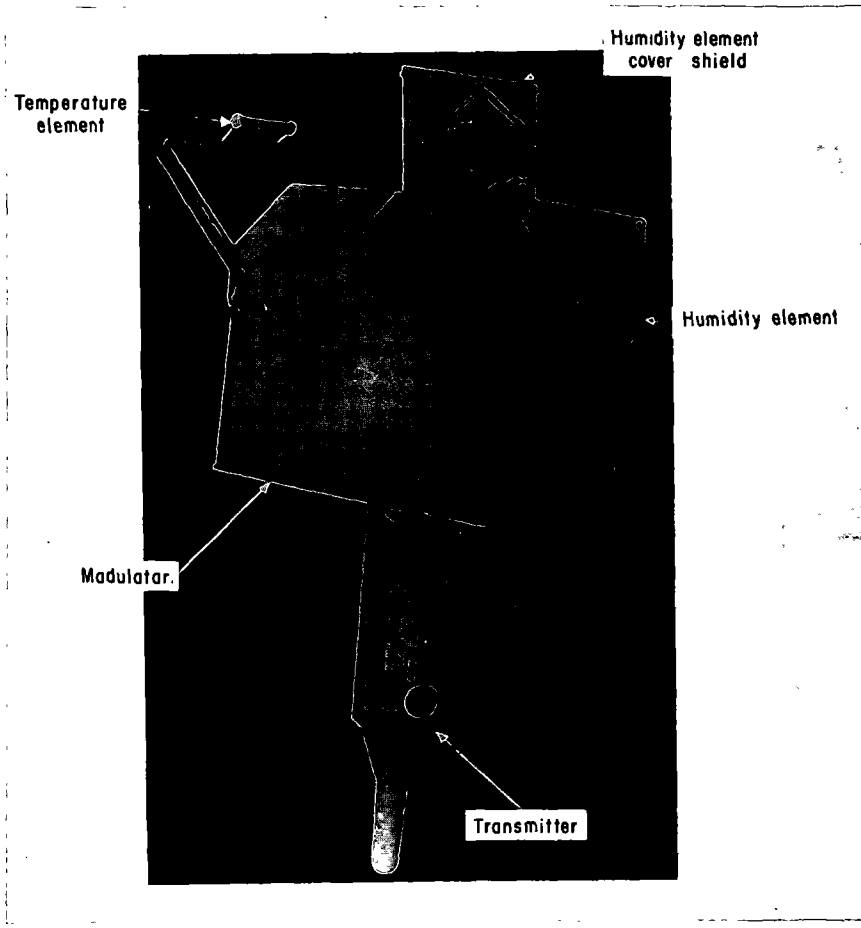


Figure 50. Radiosonde.

c. Reference. TM 11–6660–206–10, Operator Maintenance Repair Parts and Special Tools List: Rawin Set AN/GMD–1, AN/GMD–1A, and AN/GMD–1B.

5. Radiosonde Recorder AN/TMQ–5

a. Purpose. The radiosonde recorder AN/TMQ–5 (fig. 52) is an assembly of electronic and electromechanical devices which receives meteorological data from rawin set AN/GMD–1( ). The input signal for this recorder is in the form of audio-frequency pulses that normally range from 10 to 200 cycles per second. The incoming signals are converted into direct current voltages. These voltages excite a servosystem that positions a pen in the recorder and causes a graph to be plotted on calibrated paper. The entire operation functions so that the pen always marks the chart at a

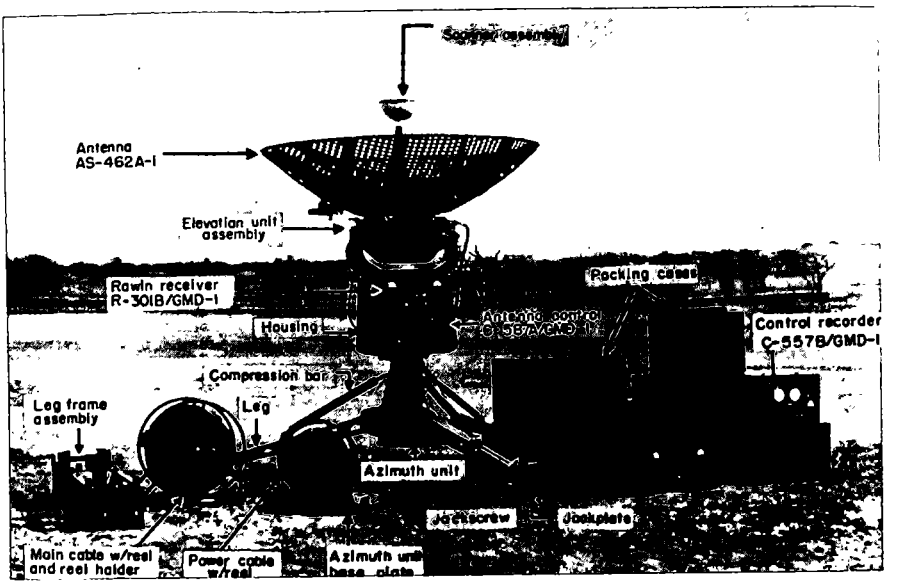


Figure 51. Rawin Set AN/GMD–1 ( ).

point which corresponds to meteorological data transmitted by the balloonborne radiosonde. A preflight calibration establishes the relationship between audio frequency and both temperature and relative humidity.

b. Technical Characteristics.

Power requirements	275 watts; 105–125 volts; 50–65 cps.
Test signal	Sine wave, 10 volts peak to peak (min).
Pen response	2½ seconds across chart.
Chart speed	½ or 1 inch + per minute.
Operating temperature	−40° to +52° Celsius.

c. Reference. TM 11–2436, Radiosonde Recorder AN/TMQ–5A, AN/TMQ–5B, and AN/TMQ–5C.

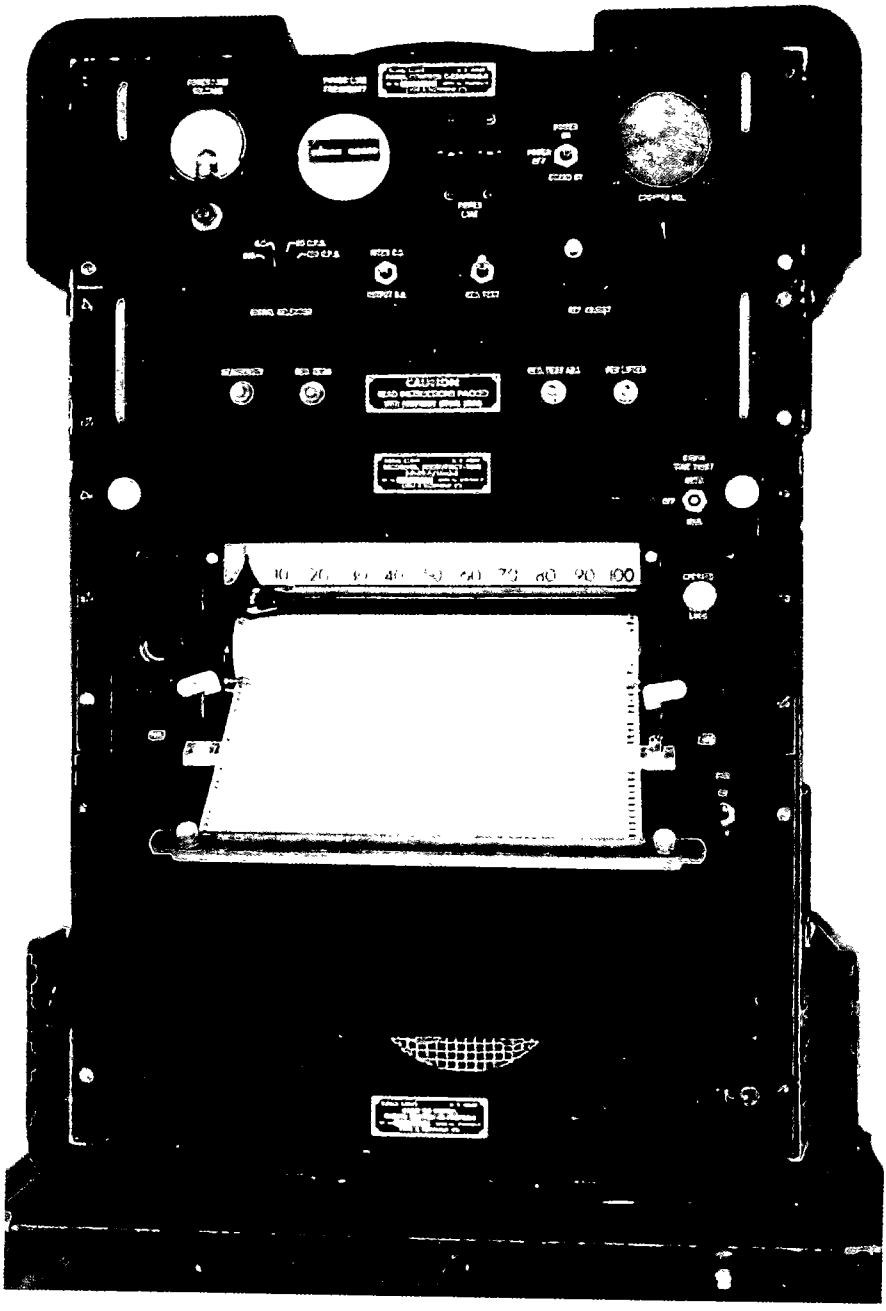


Figure 52. Radiosonde recorder AN/TMQ–5A.

Section 4. RADAR EQUIPMENT

6. Radar Set AN/MPQ–4A

a. Purpose. The radar set AN/MPQ–4A (fig. 53) is a mobile, short-range, dual-beam-intercept, nontracking countermortar radar used by the artillery to locate mortars and other high angle weapons. The set has the capability of locating mortars with a 50 meter accuracy up to a range of 10,000 meters. Although the antenna of this radar will position through 6,400 mils, the width of the area of scan is 445 mils. The AN/MPQ–4A radar can be installed in 30 to 45 minutes.

b. Technical Characteristics.

Frequency	16,000 mc ± 160 mc (K band).
Number of beams	Two.
Beam width (each beam)	Vertical–14.2 mils; horizontal–17.8 mils.
Beam separation	36 mils.

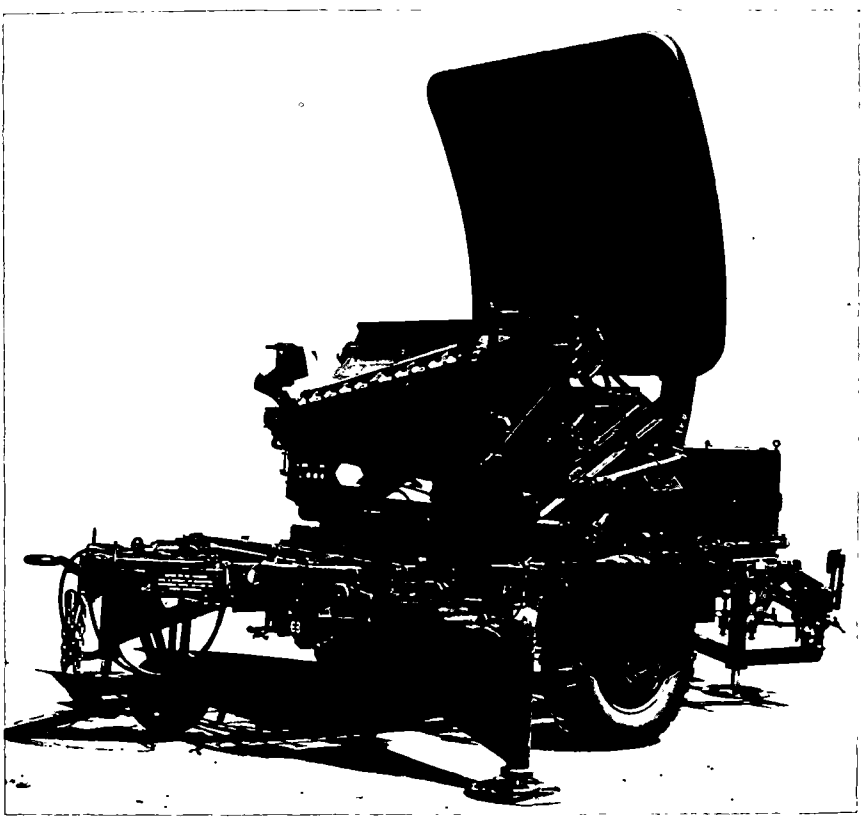


Figure 53. Radar Set AN/MPQ–4A.

Range	170 meters (min) to 10,000 meters (max).
Sector scan	445-mil fixed sector scan; antenna will position through 6,400 mils.
Power requirements	120/208 volts, 400 cycle, 3-phase supplied by trailer mounted generator set PU 304/MPQ–4. (Fuel consumption, 2.5 gallons per hour.)
Display indicator	B-Scope-displays azimuth and range strobe markers and target echoes.
Method of operation	When a projectile passes through the two radar beams, two target echoes appear on the B-scope. The operator positions both azimuth and range strobes over these echoes, at this time, an analog computer computes the easting and northing coordinates of the weapon that fired.

c. Reference.

(1) FM 6–161, Radar Set AN/MPQ–4A.

(2) TM 11–5840, 208–10, Operators Manual: Radar Set AN MPQ–4.

7. Radar Set AN/MPQ–10A

The radar set AN/MPQ–10A (fig. 54) is a countermortar radar used in a counterbattery role. Its rated range is from 450 to 18–280 meters; however, it is only effective in locating artillery to distances of approximately 10,000 meters with an accuracy of 150 to 400 meters. Although the antenna of the AN/MPQ–10A radar will position through 6,400 mils, the radar will scan automatically a sector of only 800 mils at a time. This radar can be installed in 45 to 60 minutes.

Sector scan	200 to 800 mils (selected by operator).
Effective detection and tracking ranges	Light artillery (105-mm)—8,000 meters; medium artillery (155-mm)—9,000 meters; heavy artillery (8 inch)—11,000 meters; rocket (762-mm)—18,000 meters (limited by maximum range of set).
Accuracy	Artillery locations—150 to 400 meters; mortar locations—± 50 meters.
System elements	Radar set, trailer mounted; generator PU–269/G; recorder RD–54.

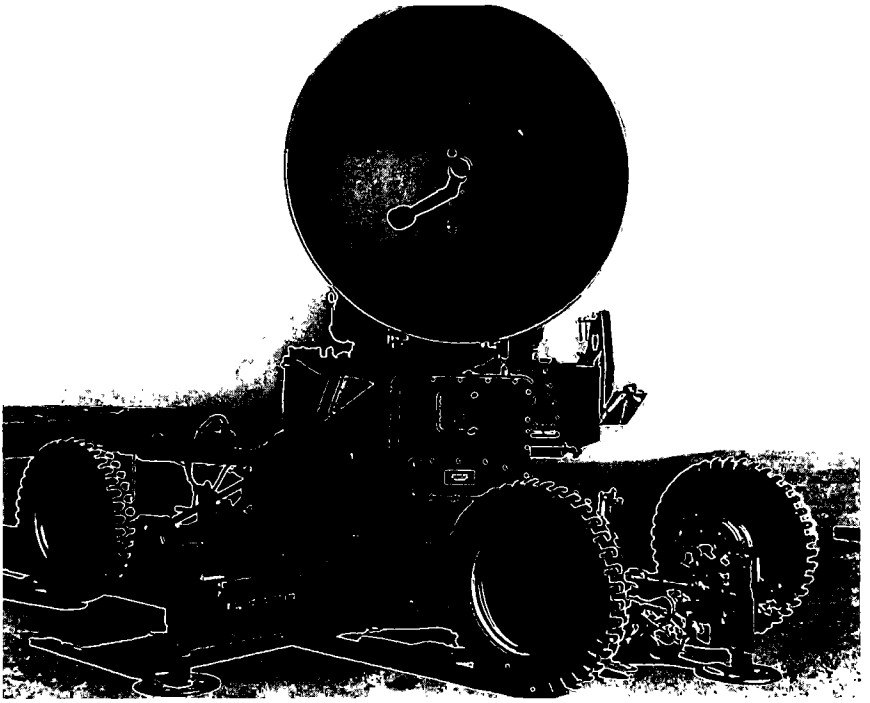


Figure 54. Radar Set AN/MPQ-10A.

Power requirements	115 volts, 60-cycle, 3-phase AC, 6 kw supplied by generator PU-269/G. (Fuel consumption 2.2 gallons per hour.)
Display indicators	B-scope, sweep range—10,000 and 20,000 yards; J-scope, sweep range—2,000 yards.
Rounds required for target location	Two rounds.
Method of operation	Initially the radar beam sector scans an area 200 to 800 mils wide. When a projectile passes through the sectoring beam, the set is taken out of sector scan and positioned at the appropriate azimuth and range to a point in the sky through which the projectile passed. When a second round is fired from the same weapon, the radar locks on to the projectile and automatically tracks it through a portion of its trajectory. During automatic tracking, the Recorder RD-54 prints a plot of the height, horizontal range, and azimuth of the

projectile. This plot is used to determine the location of the firing weapon.

FM 6–160, Radar Set AN/MPQ–10.

8. Radar Set AN/TPS–25

a. Purpose. Radar set AN/TPS–25 (fig. 55) is a transportable ground surveillance radar set capable of detecting and identifying moving ground targets at ranges between 450 and 18,280 meters. The set is completely contained and transported in a shelter mounted on a 1½-ton trailer. The antenna may be raised to 25 feet on three mast sections provided as standard equipment. One man operates the set. A seven man crew can prepare the set for operation in 15 minutes if the antenna is mounted on the transmitter-receiver unit, and in approximately 45 minutes if three mast sections are used.

b. Technical Characteristics.

Frequency	9375 mc (fixed frequency, noncoherent doppler, moving target indicator (MTI) principle).
Range	450 to 18280 meters (vehicles); 450 to 4,500 meters (personnel).
Beam width	10° search; 2° track.

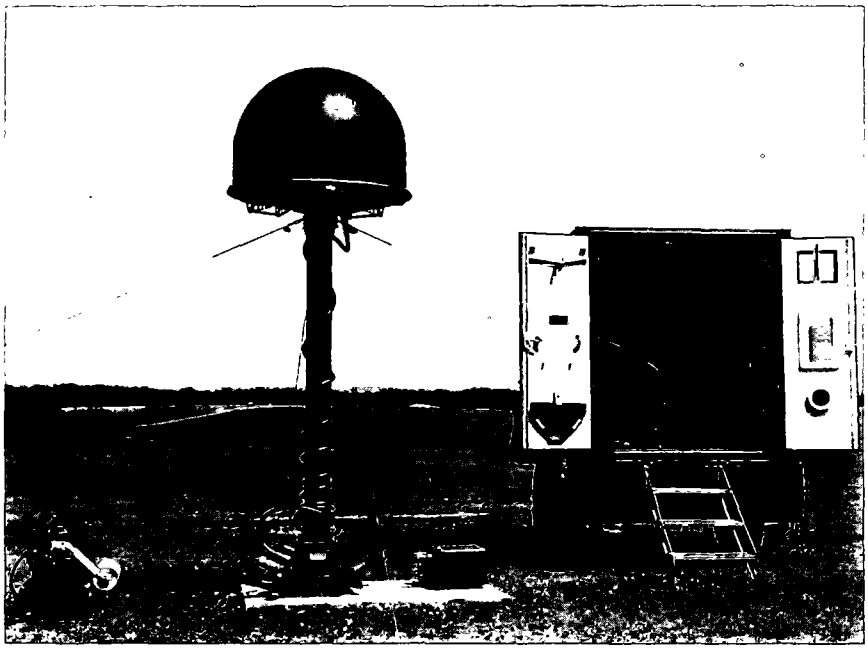


Figure 55. Radar set AN/TPS–25.

Power requirements	115 volts, 400-cycle, supplied by a portable generator. (Fuel consumption, 0.5 gallons per hour.)
Weight	2,660 pounds, including shelter.

c. Method of Operation. Non-coherent doppler systems like the AN/TPS–25 use the return from stationary objects (clutter) as a reference. The difference between the two signals is detected and, after amplification, applied to earphones and/or a loudspeaker where it is converted into sound. It is primarily from this sound that the operator is able to detect and identify moving targets. Target locations are presented on range, azimuth, and elevation counters and on Cartesian (X and Y) coordinate counters. The location of the target is also indicated on a battle map by a dot of light shining through the map at the target location. This presentation is especially useful in tracking a moving target as it tracks the direction of motion of the target. This enables the operator to predict target arrival time at a given point upon which fire can be delivered. Other aspects of operation are similar to other pulse-modulated radar sets.

d. Reference. TM 11–5840–217–10, Operators Manual: Radar Set AN/TPS–25, FM 6–162.

Section 5. SOUND RANGING EQUIPMENT

9. Sound Ranging Set GR–8

a. Purpose. Sound ranging set GR–8 (fig. 56) locates the position of artillery by measuring the relative times at which a sound wave (generated by the firing of an artillery piece) reaches a number of accurately located detection positions on the ground. The sound ranging system can be used for—

(1) Location of hostile artillery.
(2) Registration and adjustment of friendly artillery.
(3) Visual observation of the battlefield area by sound ranging personnel produces additional battlefield information thereby contributing to the overall target acquisition effort.

b. Technical Characteristics.

Operating range	Approximately 10,000 meters; width. Approximately 20,000 meters depth limited by intensity of sound.
Accuracy	Between 50 and 150 meters.
Types of sound recorded	Artillery muzzle blast, artillery shell detonation, and other heavy detonations.
System elements	Observation posts, microphone array, and command post.

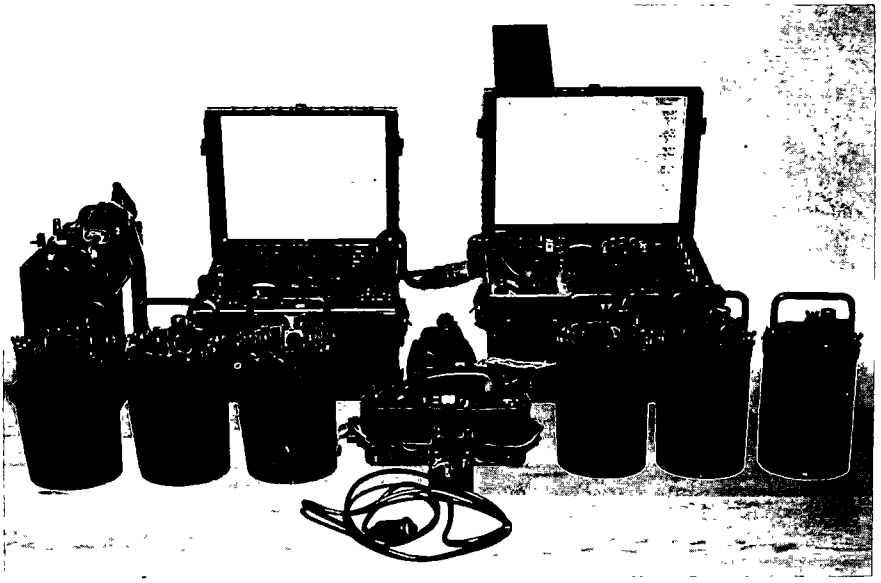


Figure 56. Sound Ranging Set, GR–8.

Interelement link (command post to microphone array)	Wire link, radio link or both.
Communication link (between command post and outpost)	Wire or radio.

c. Reference.

(1) TM 11–5895–213–10, Operators Manual: Sound Ranging Set GR–8.

(2) FM 6–122, Artillery Sound Ranging and Flash Ranging.

Section 6. SURVEY EQUIPMENT

10. Artillery Gyro Azimuth Surveying Instrument

a. Purpose. The gyro azimuth surveying instrument is designed to provide directional control in areas where such control is nonexistent and time precludes the extension of directional control through conventional techniques or visibility conditions are such that astronomic observations cannot be made to establish direction. The instrument is used at all echelons from battalion to corps to establish direction for orienting lines, to initiate a survey, to check existing directional control, and to establish declination stations.

b. Technical Characteristics. The components of the artillery gyro azimuth surveying instrument (fig. 57) are as follows:

(1) *Alinement head.* The alinement head contains a highly sensitive single-axis rate gyroscope. Direction is deter-

mined by observing the effect of rotation of the earth on the gyroscope and applying appropriate corrections. A mil graduated (0.002 mil) theodolite is mounted on the alinement head in such a manner that the horizontal circle of the theodolite is locked to the movement of the alinement head. This permits the determination of the azimuth of any line after orientation of the alinement head has been completed. The alinement head weighs 61 pounds.

(2) *Electronic package.* The electronic package converts the power from the power source to a usable power to revolve the gyroscope in the alinement head. A power source of 24 volts direct current or 110 volts alternating current may be used. The control panel of the electronic package contains the controls necessary to operate the gyroscope. The electronic package weighs 52 pounds.

(3) *Tripod and connecting cables.* The tripod is a heavy duty, specially designed tripod. It is equipped with either wooden legs or short metal legs to allow operation of the instrument under a wide scope of situations. With wooden legs, the tripod weighs 29 pounds; with metal legs, 21 pounds. Sufficient cables are provided to connect the electronic package to the alinement head and to connect the power source to the electronic package.

c. Reference.

(1) FM 6–2, Field Artillery Survey.

(2) TM 5–6675–205–15.

11. Theodolite, T2 (0.002 mil)

(fig. 58)

a. Purpose.

(1) The T2 theodolite is designed to provide division artillery, corps artillery, and certain missile battalion survey parties with a precise, mil-measuring instrument.

(2) The T2 theodolite is used to obtain angular values in artillery surveys executed to fourth order accuracy (1:3000) or higher. It is also used to extend directional control in units where directional requirements are so stringent they preclude the use of the T16 theodolite or other angle-measuring instruments. The T2 theodolite can be used in traverse, triangulation, and resection operations as well as in astronomic observations for direction.

b. Technical Characteristics. T2 theodolite is a compact, lightweight, dustproof, optical-reading, direction type instrument. It

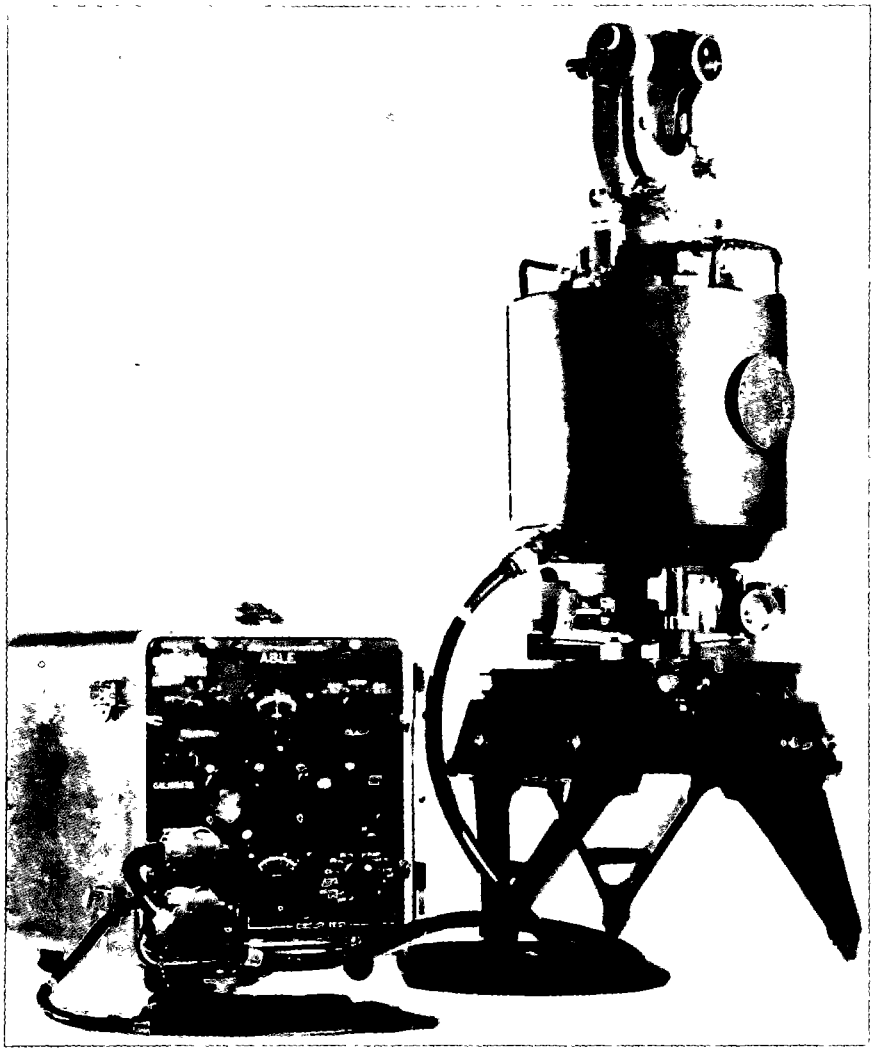


Figure 57. Artillery gyro azimuth surveying instrument.

is not designed to have a repeating capability. The scales, graduated in mils, are readable directly to 0.002 mil and by estimation to 0.001 mil. The vertical and horizontal scales are read through the use of a circle-reading microscope. They cannot be read simultaneously, but the desired scale can be selected for reading through the use of a circle selector knob. The scales may be illuminated by sunlight or artificial light. An optical plumb system is provided for centering the theodolite over a station. The instrument is equipped with horizontal and vertical motion clamps and tangent screws to

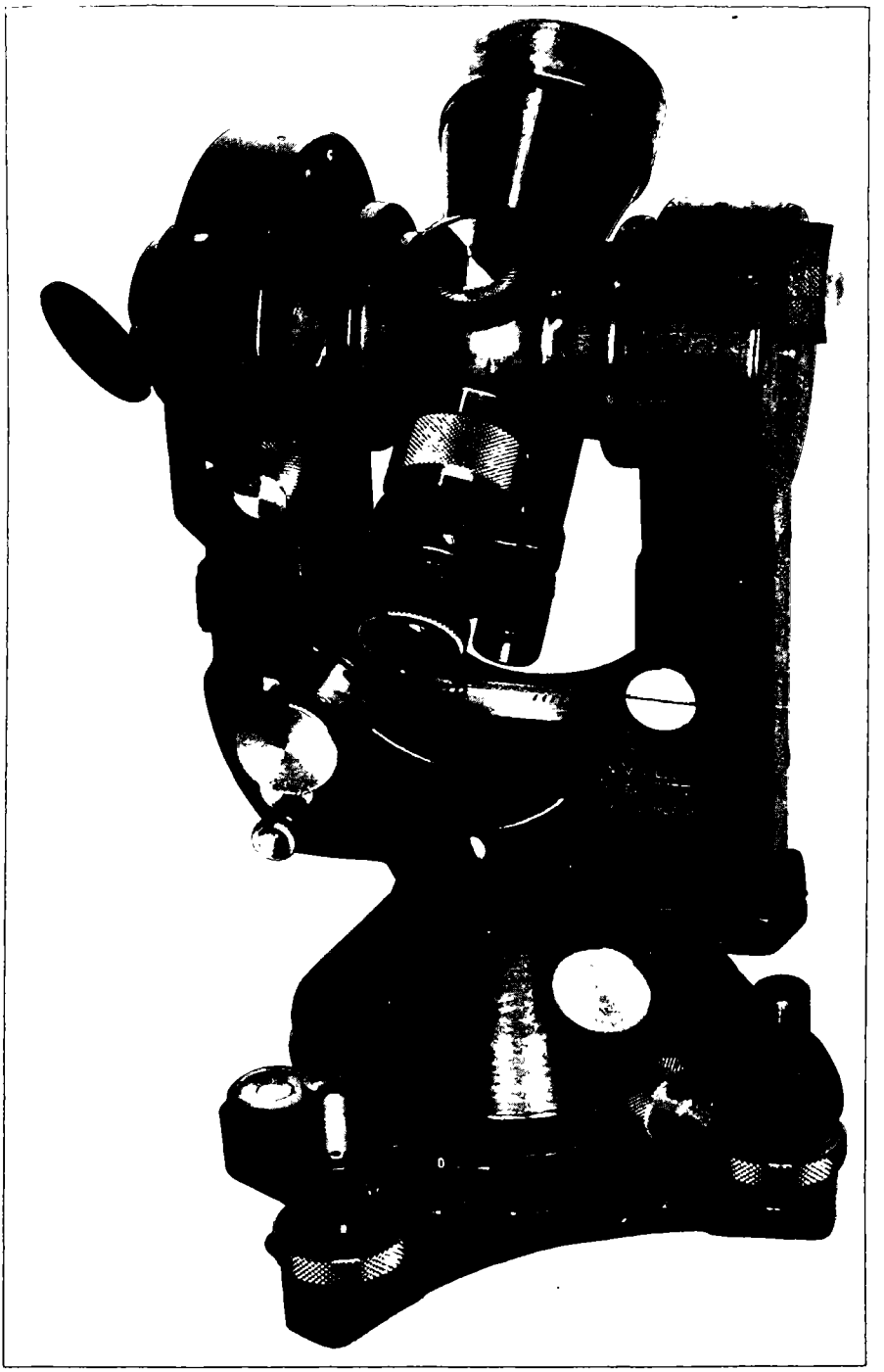


Figure 58. Theodolite, T2.

provide fast and slow motions. The telescope is a 28-power telescope and all images viewed are inverted. The instrument is equipped with a detachable tribrach which permits installation of other precise instruments without releveling. The tripod for the instrument is the standard Wild tripod and can be used with other model theodolites and precise equipment.

c. Reference.

(1) FM 6–2, Field Artillery Survey.

(2) TM 5–6675–213–12, Operators and Organizational Maintenance Manual.

12. Theodolite, T16 (0.2 mil)

(fig. 59)

a. Purpose.

(1) The T16 theodolite is designed to provide all artillery battalions with a primary surveying instrument to replace the transit. Due to the construction of the T16 theodolite, more precise measurements can be obtained in shorter periods of time when compared with the transit.

(2) The T16 is used to obtain angular values in artillery surveys executed to fifth order accuracy (1:1000). It can be used in traverse, triangulation, and resection operations as well as in astronomic observations for direction.

b. Technical Characteristics. The T16 theodolite is a compact, lightweight, dustproof, optical-reading, direction type instrument with a repeater clamp for measuring horizontal angles. The scales, graduated in mils, are readable directly to 0.2 mil and by estimation to the nearest 0.1 mil. The vertical and horizontal scales are read simultaneously through the use of a circle-reading microscope and they may be illuminated by sunlight or artificial light. An optical plumb system is provided for centering the theodolite over a station. The instrument is equipped with horizontal and vertical motion clamps and tangent screws to provide fast and slow motions. The telescope is a 28-power telescope and all images viewed are inverted. The instrument is equipped with a detachable tribrach which permits installation of other precise instruments without releveling. The tripod for the instrument is the standard Wild tripod and can be used with other model theodolites and precise equipment.

c. Reference.

(1) FM 6–2, Field Artillery Survey.

(2) TM 5–6675–200–12, Operators and Organizational Maintenance Manual.

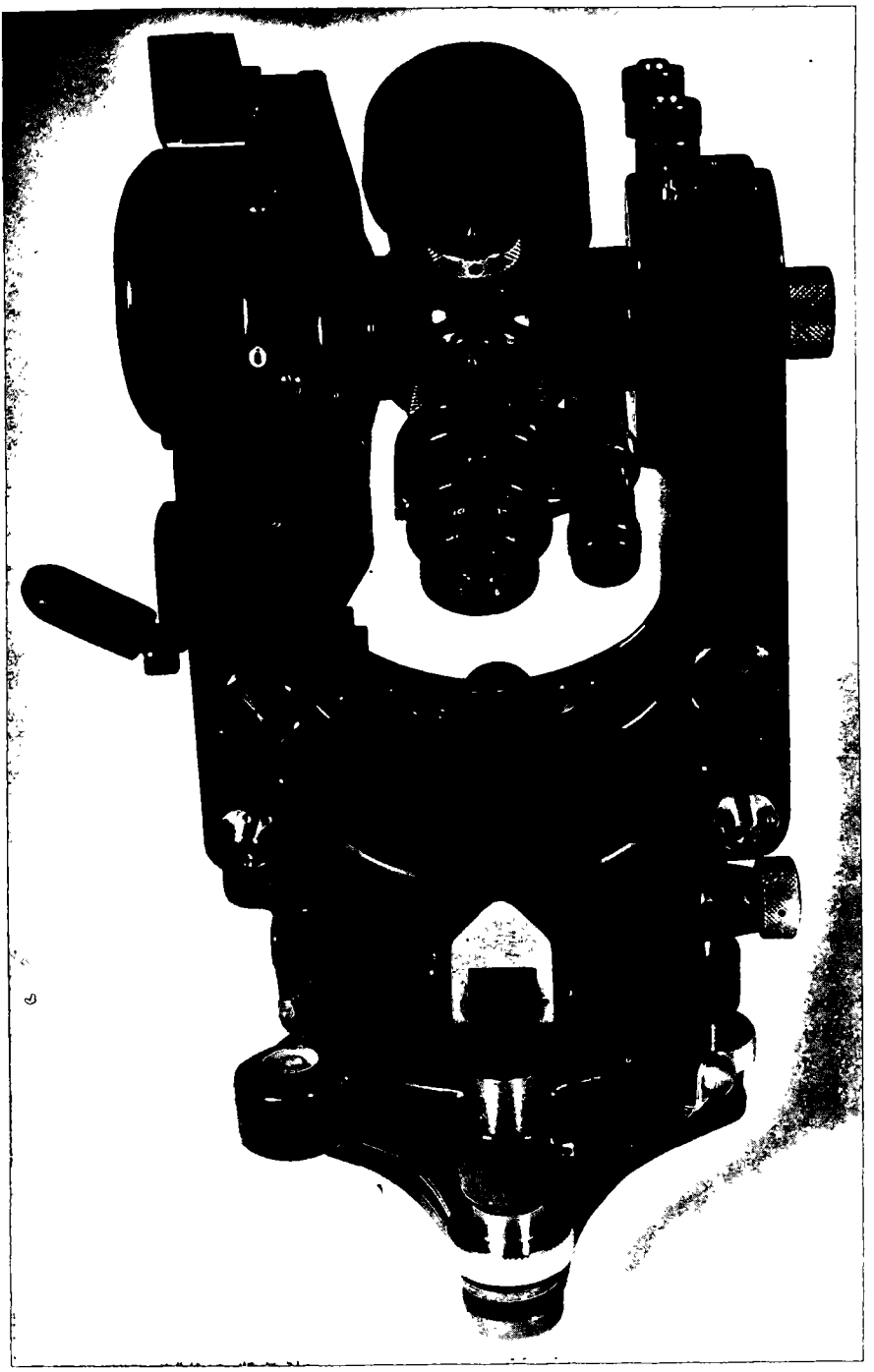


Figure 59. Theodolite, T16.

13. Tellurometer Electronic Distance Measuring Equipment

(fig. 60)

a. Purpose. The tellurometer is designed to provide an electronic distance measuring capability to division artillery and corps artillery survey parties. It can be used to measure distances from 152 meters to 64,000 meters with accuracy better than 1:10,000. It is used to extend coordinate control over great distances under all conditions of visibility and weather. The reduction in time required for distance measuring enables division artillery surveyors to provide more extensive and more timely control and areas requiring control.

b. Technical Characteristics. The tellurometer employs a phase comparison technique to determine the transit time of radio microwaves from one point to another and return. This transit time is then converted to distance. The system employs a master unit and two remote units. The master unit and one remote unit are required to measure a distance. The master and remote units are similar in appearance and weight but they cannot perform the same functions. Each unit weighs 27 pounds. Each has a lightweight aluminum-alloy carrying case which weighs approximately 18 pounds. The system operates on 12 volt or 24 volt direct current or 115 volt 60 cycle alternating current. The master unit is equipped with a cathode ray tube which is graduated in millimicroseconds. It is used to read the transit time of the microwaves on each of four pattern crystals. Each crystal represents a portion of the distance, i.e., A–15 meters, B–15000, C–1500, and D–150 meters. By combining the transit times obtained on each crystal, the total transit time can be determined. The complete operation from setting up the equipment to computation of the distance can be accomplished in 30 minutes, regardless of the distance involved. A built-in communication system is provided for master-remote voice communication. When the instruments are alined on each other, the operators may communicate with each other to distances approaching 65 miles.

c. References.

(1) FM 6–2, Field Artillery Survey.

(2) TM Eng 23, Use of the Tellurometer in Military Surveying.

(3) Operation and Field Maintenance Handbook, Microwave System of Distance Measurements by Tellurometer Limited.

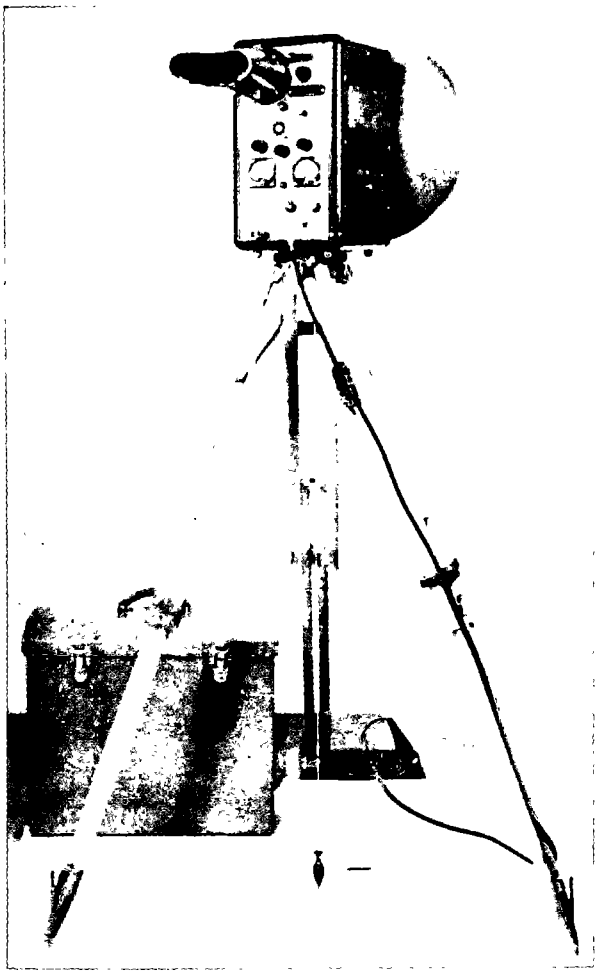


Figure 60. Tellurometer electronic distance measuring equipment.

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NG: State AG (3); units—same as Active Army except allowance is one copy to each unit.

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For explanation of abbreviations used, see AR 320–50.

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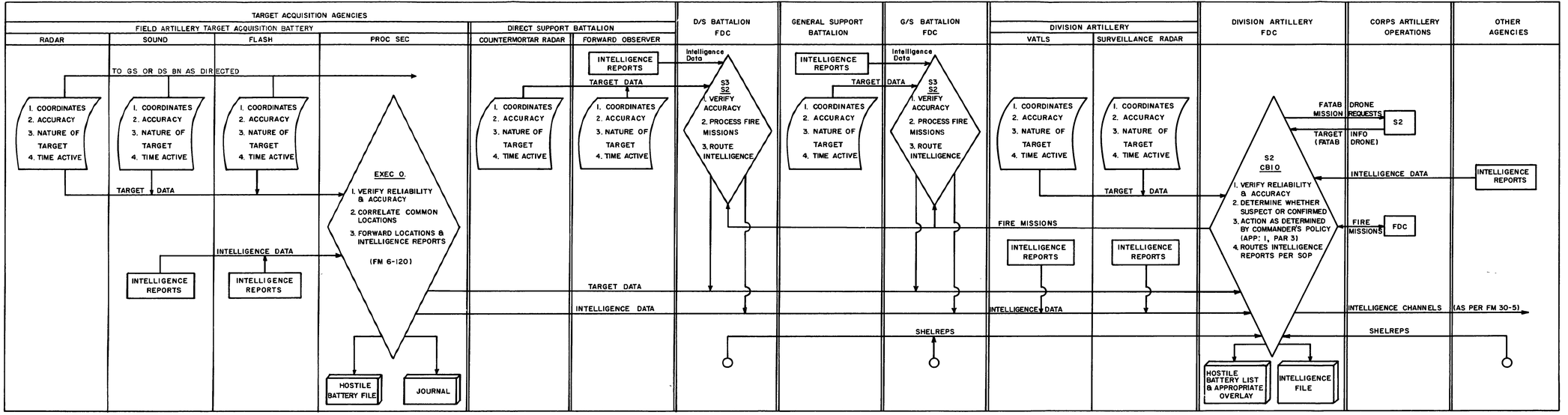

Figure 8. Artillery data flow (Target Acquisition Battery Attached).

Figure 8.

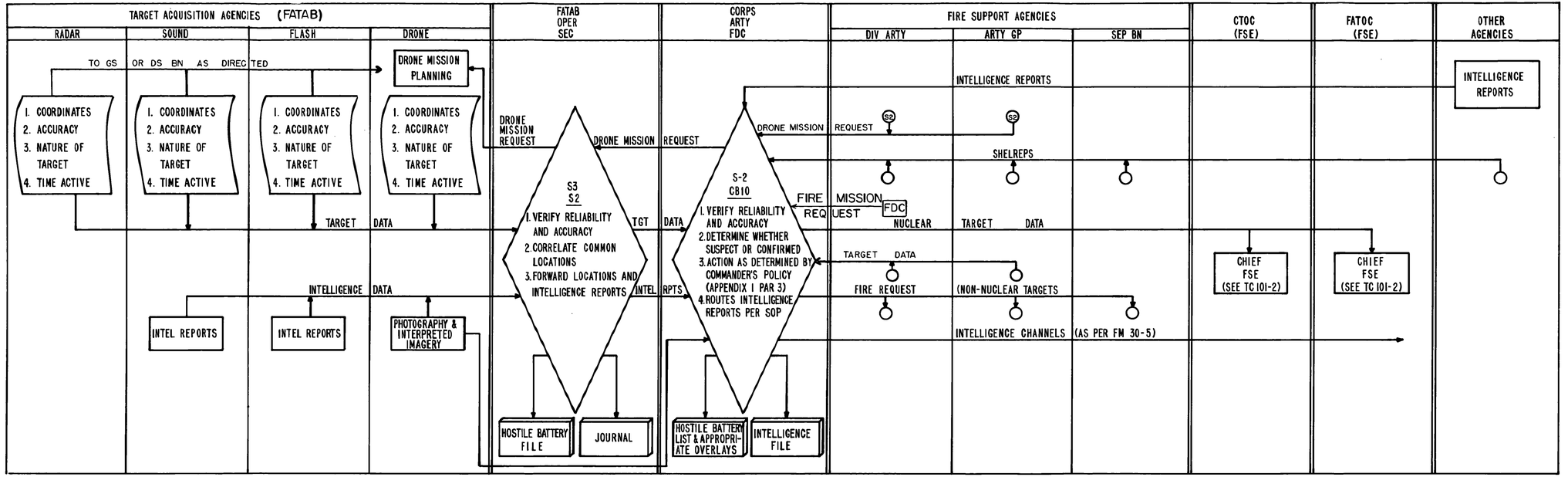

Figure 9. Corps artillery data flow chart (FATAB in support of Corps Arty).

Figure 9.

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